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THOMAS HENRY HUXLEY

A SKETCH OF HIS LIFE AND WORK

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CONTENTS

CHAP.		PAGE
	PREFACE TO THE FIRST EDITION	7
	PREFACE TO THE SECOND EDITION	9
I.	FROM SCHOOL TO LIFE-WORK	15
II.	THE VOYAGE OF THE "RATTLESNAKE"	27
III.	FLOATING CREATURES OF THE SEA	42
IV.	EARLY DAYS IN LONDON	55
V.	CREATURES OF THE PAST	76
VI.	HUXLEY AND DARWIN	95
VII.	THE BATTLE FOR EVOLUTION	115
VIII.	VERTEBRATE ANATOMY	131
IX.	MAN AND THE APES	144
X.	SCIENCE AS A BRANCH OF EDUCATION	164
XI.	GENERAL PROBLEMS OF EDUCATION	183
XII.	CITIZEN, ORATOR, AND ESSAYIST	197
XIII.	THE OPPONENT OF MATERIALISM	210
XIV.	FREEDOM OF THOUGHT	223
XV.	THE BIBLE AND MIRACLES	235
XVI.	ETHICS OF THE COSMOS	249
XVII.	CLOSING DAYS AND SUMMARY	261
	INDEX	271

PREFACE TO THE FIRST EDITION

THIS volume is in no sense an intimate or authorised biography of Huxley. It is simply an outline of the external features of his life and an account of his contributions to biology, to educational and social problems, and to philosophy and metaphysics. In preparing it, I have been indebted to his own Autobiography, to the obituary notice written by Sir Michael Foster for the Royal Society of London, to a sketch of him by Professor Howes, his successor at the Royal College of Science, and to his published works. The latter consist of many well-known separate volumes which are familiar to all zoologists, and of a vast number of memoirs and essays scattered in various scientific and general publications. The general Essays were collected into nine volumes, revised by himself in the later years of his life, and published by Messrs. Macmillan. The Scientific Memoirs, thanks to the generous enterprise of the same publishing firm, with which he was so long associated, and to the pious labours of Sir Michael Foster and Professor Ray Lankester, are in process of reissue in the form of four volumes, two of which have now appeared. These will contain all his important

contributions to science, with the exception of a large separate treatise on the *Oceanic Hydrozoa*, published by the Ray Society in 1859. There is also announced a formal Biography, prepared by his son, so that future admirers or students of Huxley's work will be in an exceptionally favourable position.

P. CHALMERS MITCHELL.

LONDON, 1900.

PREFACE TO THE SECOND EDITION

THE first edition of this book was published in 1901 in London and New York by Messrs. G. P. Putnam's Sons as a volume in their Leaders of Science Series. It has now been transferred, by their courtesy, to Messrs. Methuen & Co. It has been carefully revised, and I have been able to add a number of personal details from Mr Leonard Huxley's invaluable "Life and Letters" of his father, which had not appeared when I wrote my little volume. The book, however, was designed to be, and remains, more a sketch of Huxley's work and influence, than of his personality. As such it has, I believe, some historical value. Not only biological science, but human thought, passed through a fundamental change during the lifetime of Huxley, and although it was the patient genius of Darwin that made the revolution possible, it was the virile mastery of Huxley that made it actual. In all the ferment and swift progress of biological thought since Huxley finished his life-work, there is nothing, taken even at the valuation of its advocates, so potent as the wine of Darwinism.

P. C. M.

LONDON, *October* 1912.

SHORT BIBLIOGRAPHY

THIS list is offered, not as a bibliography in the technical sense, but as an indication of the sources in which the vast majority of Huxley's scientific and general work may be consulted most conveniently.

The Scientific Memoirs of Thomas Henry Huxley. Edited by Professor Sir Michael Foster and Professor E. Ray Lankester; in four volumes. London, Macmillan & Co.; New York, D. Appleton.

This magnificent collection was designed to contain all Huxley's original scientific papers, brought together from the multitude of scientific periodicals in which they appeared, with reproductions of the original illustrations. The only exception is the monograph on *Oceanic Hydrozoa*. The first volume appeared in 1898; the second in 1899, and the others are to follow quickly.

Collected Essays by T. H. Huxley; nine volumes of the Eversley Series. Macmillan & Co. London, 1893-95.

This set, edited by Huxley himself, contains the more important of his least technical contributions to science and his literary, philosophical, and political and critical essays. Each volume has a preface specially written, and the first volume contains his autobiography.

The Oceanic Hydrozoa; a description of the Calycophoridæ and Physophoridæ observed during the Voyage of H.M.S. *Rattlesnake* in the years 1846-50, with a general introduction. Ray Society. London, 1859.

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THOMAS HENRY HUXLEY

CHAPTER I

FROM SCHOOL TO LIFE-WORK

SOME men are born to greatness: even before their arrival in the world their future is marked out for them. All the advantages that wealth and the experience of friends can bring attend their growth to manhood, and their success almost loses its interest because of the ease with which it is attained. Few of the leaders of science were in such a position: many of them, such as Priestley, Davy, Faraday, John Hunter, and Linnæus were of humble parentage, and received the poorest education: most of them, like Huxley himself, came from parents who were able to do little more for their children than to send them into life along the ordinary educational avenues. In Huxley's boyhood a moderate income was still necessary for this: in every civilised country nowadays, state or private endowments are ready to help every capable boy, as far as Huxley was helped, and in his progress from boyhood to supreme distinction, there is nothing that cannot be emulated by every boy at school to-day. The minds of human beings when they are born into the world are as naked as their bodies; it matters not if parents, grandparents, and remoter ancestors were unlettered or had the wisdom of all the ages, the new mind has to build up its own wisdom from the beginning. We cannot even say with certainty,

that children inherit mental aptitudes and capacities from their parents; for as tall sons may come from short parents or beautiful daughters from ugly parents, so we may find in the capacities of the parents no trace of the future greatness of their children. None the less it is interesting to learn what we can about the parents of great men; and Huxley tells us that he thinks himself to have inherited many characters of his body and mind from his mother.

Thomas Henry Huxley was born on the 4th of May, 1825, at Ealing, then a little country village, now united to London as a great suburb. He was the seventh child of George Huxley, second master at the school of Dr. Nicholson at Ealing. In these days private schools were numerous in England, and this establishment seems to have been of high-class character, for Cardinal Newman and many other distinguished men received part of their education there. His mother, whose maiden name was Rachel Withers, was, he tells us himself:*

"A slender brunette of an emotional and energetic temperament, and possessed of the most piercing black eyes I ever saw in a woman's head. With no more education than other women of the middle classes in her day, she had an excellent mental capacity. Her most distinguishing characteristic, however, was rapidity of thought. If one ventured to suggest she had not taken much time to arrive at any conclusion, she would say, 'I cannot help it. Things flash across me.' That peculiarity has been passed on to me in full strength: it has often stood me in good stead: it has sometimes played me sad tricks, and it has always been a danger. But, after all, if my time were to come over again there is nothing I would less willingly part with than my inheritance of 'mother wit.'"

---

* This and many other details in this chapter are taken from an autobiographical sketch in the first volume of Huxley's collected essays published by Macmillan, London, 1894.

In this edition, certain additional details are added from "Life and Letters of Thomas Henry Huxley," by his son Leonard Huxley; 2 vols., Macmillan & Co., London, 1900.

From his father he thinks that he inherited little except an inborn capacity for drawing, "a hot temper, and that amount of tenacity of purpose which unfriendly observers sometimes call obstinacy." Huxley was well aware of his own disposition, and frequently warned his friends against undue combativeness. In a letter to Sir Ray (then Professor) Lankester, in 1888, who was meditating going from Oxford to London, he wrote, after a little jest about the need for Oxford to be stirred up, and for Lankester to be smoothed down: "Seriously, I wish you would let an old man, who has had his share of fighting, remind you that battles, like hypotheses, are not to be multiplied beyond necessity. Science might say to you as the Staffordshire collier's wife said to her husband at the fair, 'Get thee foighten done and come whoam.' You have a fair expectation of ripe vigour for twenty years; just think what may be done with that capital.

"No use to *tu quoque* me. Under the circumstances of the time, warfare has been my business and duty."—"Life and Letters," II. p. 213.

He could not learn to suffer fools gladly. As he said himself, he loved his friends and hated his enemies, and his hasty disposition often made him see an enemy in a merely stupid or dilatory opponent, and those who had to bear the sudden brunt of his displeasure or reproof were almost paralysed by the crushing and contemptuous severity his personality could emit. Equally, however, the real sweetness of his nature made him beloved by his family circle, by his familiar friends, and by all of those with whom he had to work. His inherited gift for drawing proved of the greatest service to him throughout his career. It is imperative that every investigator of the anatomy of plants and animals should be able to sketch his observations, and there is no greater aid to seeing things as they are than the continuous attempt to reproduce them by pencil or brush. He used it for less serious purposes, and his letters to his children or to his friends were often adorned

with gay or humorous little ink sketches caricaturing or illustrating what he had to say.

Huxley was christened Thomas Henry, and he was unaware why these names were chosen, but he humorously records the curious chance that his parents should have chosen for him the "name of that particular apostle with whom he had always felt most sympathy."

Of his childhood little is recorded. He remembers being vain of his curls, and his mother's expressed regret that he soon lost the beauty of early childhood. He attended for some time the school at Ealing with which his father was associated, but he has little to say for the training he received there. He writes:

"My regular school training was of the briefest, perhaps fortunately; for, though my way of life has made me acquainted with all sorts and conditions of men, from the highest to the lowest, I deliberately affirm that the society I fell into at school was the worst I have ever known. We boys were average lads with much the same inherent capacity for good and evil as any others; but the people who were set over us cared about as much for our intellectual and moral welfare as if they were baby-farmers. We were left to the operation of the struggle for existence among ourselves, and bullying was the least of the ill practices current among us. Almost the only cheerful reminiscence in connection with the place which arises in my mind is that of a battle which I had with one of my class-mates, who had bullied me until I could stand it no longer. I was a very slight lad, but there was a wild-cat element in me which, when roused, made up for my lack of weight, and I licked my adversary effectually. However, one of my first experiences of the extremely rough and ready nature of justice, as exhibited by the course of things in general, arose out of the fact that I—the victor—had a black eye, while he—the vanquished—had none, so that I got into disgrace and he did not. One of the greatest shocks I ever received in my life was to be told, a dozen years afterwards, by the groom who brought me my horse in a stableyard in Sydney, that he was my quondam antagonist. He had a long story of family misfortune to account for his position—but at that time it was necessary to deal very cautiously with mysterious strangers in New South Wales, and

on enquiry I found that the unfortunate young man had not only been 'sent out,' but had undergone more than one colonial conviction."

His memory of his schooldays never left him, but inspired him not only when, as member of the first School Board of London, he had to deal with the elementary education of the lower classes, but when as Governor of Eton, he had to consider the choice of a new headmaster, and the influence that the selection might make on the most famous school in the world.

Huxley was soon removed from school and continued his own education for several years, by reading of the most desultory sort. His special inclinations were towards mechanical problems, and had he been able to follow his own wishes there is little doubt but that he would have entered on the profession of an engineer. It is probable that there was a great deal more in his wishes than the familiar inclination of a clever boy to engineering. All through his subsequent pursuit of anatomy, it was the structure of animals, the different modifications of great ground-plans which they presented, that interested him. But the opportunity for engineering did not come his way, and at an early age he began to study medicine. Two brothers-in-law were doctors, and this accidental fact probably determined his choice. In these days the study of medicine did not begin as now with a general and scientific education, but the young medical student was apprenticed to a doctor engaged in practice. He was supposed to learn the compounding of drugs in the dispensary attached to the doctor's consulting-room, and the dressing of wounds and the superficial details of the medical craft, while he pursued his studies in anatomy under the direction of the doctor. Huxley's master was his brother-in-law, Dr. Salt, a London practitioner, and he began his work when only twelve or thirteen years of age. In this system everything depended upon the superior; under the careful guidance of a conscientious and able man it was possible for an apt pupil to learn a great deal of science and to become

an expert in the treatment of disease. Huxley, however, had only a short experience of this kind of training. He was taken by some senior student friends to a post-mortem examination, and although then, as all through his life, he was most sensitive to the disagreeable side of anatomical pursuits, on this occasion he gratified his curiosity too ardently. He did not cut himself, but in some way poisonous matter from the body affected him, and he fell into so bad a state of health that he had to be sent into the country to recruit. He lived for some time at a farmhouse in Warwickshire with friends of his father, and slowly recovered health. From that time, however, all through his life, he suffered periodically from prostrating dyspepsia. After some months devoted to promiscuous reading he resumed his work under his brother-in-law in London. He confesses that he was far from a model student.

"I worked extremely hard when it pleased me, and when it did not—which was a frequent case—I was extremely idle (unless making caricatures of one's pastors and masters is to be called a branch of industry), or else wasted my energies in wrong directions. I read everything I could lay hands upon, including novels, and took up all sorts of pursuits to drop them again quite speedily."

It is almost certain, however, that Huxley underestimated the value of this time. He stored his mind with both literature and science, and laid the foundation of the extremely varied intellectual interests which afterwards proved of much value to him. It is certain, also, that during this time he acquired a fair knowledge of French and German. It would be difficult to exaggerate the advantage of this addition to his weapons for attacking knowledge. To do the best work in any scientific pursuit it is necessary to freshen one's own mind by contact with the ideas and results of other workers. As these workers are scattered over different countries it is necessary to transcend the confusion of Babel and read what they write in their own tongues. When Huxley was young, the great reputation of Cuvier overshadowed English ana-

tomy, and English anatomists did little more than seek in nature what Cuvier had taught them to find. In Germany other men and other ideas were to be found. Johannes Müller and von Baer were attacking the problems of nature in a spirit that was entirely different, and Huxley, by combining what he was taught in England with what he learned from German methods, came to his own investigations with a wider mind. But his conquest of French and German brought with it advantages in addition to these technical gains. He acquired them simply to discover the new ideas concealed in them, and he by no means confined himself to the reading of foreign books on the subjects of his own studies. He read French and German poetry, literature, and philosophy, and so came to have a knowledge of the ideas of those outside his own race on all the great problems that interest mankind. A good deal has been written as to the narrowing tendency of scientific pursuits, but with Huxley, as with all the scientific men the present writer has known, the mechanical necessity of learning to read other languages brought with it that wide intellectual sympathy which is the beginning of all culture and which is not infrequently missed by those who have devoted themselves to many grammars and a single literature. The old proverb, "Whatever is worth doing is worth doing well," has only value when "well" is properly interpreted. Although the science of language is as great as any science, it is not the science of language, but the practical interpretation of it, that is of value to most people, and there is much to be said for the method of anatomists like Huxley, who passed lightly over grammatical *minutiæ* and went straight with a dictionary to the reading of each new tongue. He began to learn Greek late in middle life, partly because he wished to read Aristotle in the original, to see for himself if mistakes attributed to that great anatomist were not really blunders resulting from the ignorance of his classically educated translators, a suspicion which he found just. Huxley's method was to read in

his book until he had come to ten new words; the looking up, parsing and transcribing of these completed his daily portion.

After a short period of apprenticeship, or sometimes during the course of it, young medical students "walked" a hospital. This consisted in attending the demonstrations of the physicians and surgeons in the wards and in pursuing anatomical, chemical, and physiological study in the medical school attached to the hospital. A large fee was charged for the complete course, but at many of the hospitals there were entrance scholarships which relieved those who gained them of all cost. In 1842 Huxley and his elder brother, James, applied for such free scholarships at Charing Cross Hospital. The entry in the minutes for September 6, 1842, states that

"Applications from the following gentlemen (including the two sons of Mr. George Huxley, late senior assistant master in Ealing School), were laid before the meeting, and their testimonials being approved of, it was decided that those gentlemen should be admitted as free scholars, if their classical attainments should be found upon examination to be satisfactory."

It appears that the two Huxleys were able to satisfy the probably unexacting demands of the classical examiners, for they began their hospital work in October of the same year.

Those who know the magnificent laboratories and lecture-rooms which have grown up in connection with the larger London hospitals must have difficulty in realising the humble arrangements for teaching students in the early forties. What endowments there were—and Charing Cross was never a richly endowed hospital—were devoted entirely to the hospital as opposed to the teaching school. There were no separate buildings for anatomy, physiology, and so forth. At Charing Cross the dissecting-room was in a cellar under the hospital, and subjects like chemistry, botany and physiology were crowded into inconvenient side rooms. The teachers were not specialists,

devoting their whole attention to particular branches of science, but were doctors engaged in practice, who, in addition to their private duties and their work at the hospital, undertook each to lecture upon a special scientific subject. Huxley came specially under the influence of Wharton Jones, who had begun to teach physiology at the hospital a year before. Mr. Jones throughout his life was engaged in professional work, his speciality being ophthalmic surgery, but he was a devoted student of anatomy and physiology, and made several classical contributions to scientific knowledge, his best-known discoveries relating to blood corpuscles and to the nature of the mammalian egg-cell. But perhaps his greatest claim to fame is that it was he who first imbued Huxley with a love for anatomical science and with a knowledge of the methods of investigation. At the end of his first session, in 1843, Huxley received the first prize in the senior physiology class, while his brother got a "good conduct" prize. Of Wharton Jones, Huxley writes:

"The extent and precision of his knowledge impressed me greatly, and the severe exactness of his method of lecturing was quite to my taste. I do not know that I have ever felt so much respect for anybody as a teacher before or since. I worked hard to obtain his approbation, and he was extremely kind and helpful to the youngster who, I am afraid, took up more of his time than he had any right to do. It was he who suggested the publication of my first scientific paper—a very little one—in the *Medical Gazette* of 1845, and most kindly corrected the literary faults which abounded in it short as it was. For at that time, and for many years afterwards, I detested the trouble of writing and would take no pains over it."

This little paper, although Huxley deprecates it, was remarkable as the work of so young an investigator. In it he demonstrated the existence of a hitherto unrecognised layer in the inner root-sheath of hairs, a layer that has been known since as **Huxley's layer.**

There is no record in the minutes of the hospital school that Huxley gained any other prizes. His name reappears only in formal applications at the beginning of each session for the renewal of his free scholarship. In this respect he is in marked contrast to his fellow-student, afterwards Sir Joseph Fayrer, who appears to have taken almost every prize open to him. On the other hand, his attainments in anatomy and physiology brought him distinction in a wider field than the hospital school, for he obtained, in the "honours" division of the first examination for the degree of Bachelor of Medicine at the University of London, the second place with a medal. And it is certain that he was far from neglecting his strictly professional work, although, no doubt, he devoted much time to reading and research in pure science, for in the winter of 1845-46, having completed his course at the hospital, he was prepared to offer himself at the examination for the membership of the Royal College of Surgeons; but, being as yet under twenty-one years of age, could not be admitted as a candidate.

It was now time for Huxley to enter definitely on his profession. He would have preferred to continue his investigations in London and to wait for the chance of a teaching post in physiology, but it was necessary to earn a living. One of those whom he consulted was his fellow-student, Joseph Fayrer, who, hailing from Bermuda, knew something of those that go down to the sea in ships. He advised Huxley to write to Sir William Burnett, at that time Director-General for the medical service of the navy, for an appointment.

"I thought this rather a strong thing to do," says Huxley in his autobiography, "as Sir William was personally unknown to me; but my cheery friend would not listen to my scruples, so I went to my lodgings and wrote the best letter I could devise. A few days afterwards I received the usual official circular of acknowledgment, but at the bottom was written an instruction to call at Somerset House on such a day. I thought that looked like business, so, at the

appointed time I called and sent in my card, while I waited in Sir William's ante-room. He was a tall, shrewd-looking old gentleman, with a broad Scotch accent—and I think I see him now as he entered with my card in his hand. The first thing he did was to return it with the frugal reminder that I should probably find it useful on some other occasion. The second was to ask whether I was an Irishman. I suppose the air of modesty about my appeal must have struck him. I satisfied the Director-General that I was English to the backbone, and he made some enquiries as to my student career, finally desiring me to hold myself ready for examination. Having passed this, I was in Her Majesty's service, and entered on the books of Nelson's old ship, the *Victory*, for duty at Haslar Hospital, about a couple of months after I made my application."

About the same time he passed the examination of the Royal College of Surgeons and so became a fully qualified medical man. Haslar Hospital was the chief naval hospital to which invalided sailors were sent. There was a numerous staff of young surgeons, as navy surgeons were usually sent for a term to work in the hospital before being gazetted to a ship in commission. In connection with the hospital, there was a museum of natural history containing a collection of considerable importance slowly gathered from the gifts of sailors and officers. The museum curator was an enthusiastic naturalist, and Huxley had the opportunity of extending his knowledge of at least the external characters of many forms of life hitherto unknown to him. A few years later, the curator of the museum, with the help of two of Huxley's successors, published a *Manual of Natural History for the Use of Travellers*, and it is certain that Huxley at least did not lose at Haslar any of the enthusiasm for zoology with which he had been inspired at the Charing Cross Hospital. The chief of Haslar was Sir John Richardson, an excellent naturalist, and well known as an arctic explorer. He recognised the peculiar ability of his young assistant, and although he was a silent, reserved man, who seldom encouraged his assistants by talking to them, he made several attempts to obtain a

suitable post for Huxley. Such a post was that of surgeon to H.M.S. *Rattlesnake*, then about to start under the command of Captain Owen Stanley for surveying work in the Torres Straits. Captain Stanley had expressed a wish for a surgeon who knew something of science, and, on the recommendation of Sir John Richardson, obtained the post for Huxley. There was, however, to be a special naturalist attached to the expedition, but Huxley had the opportunity he wanted. After a brief stay of seven months at the Haslar Hospital he left it for his ship, and thus definitely entered on his work in the world.

CHAPTER II

THE VOYAGE OF THE "RATTLESNAKE"

HER Majesty's ship the *Rattlesnake*, one of the old class of 28-gun ships, sailed from Plymouth for the Torres Straits and the Australian seas on December 12, 1846. Her commander was Captain Owen Stanley, a young but distinguished officer, the son of the Bishop of Norwich and a brother of Dean Stanley, who afterwards played a great part in the social and religious history of England. She carried a complement of 180 officers and men, and was attended by the *Bramble* and the *Castlereagh*, two small vessels of light draught, whose purpose was to precede her in shallow waters. The young colonies of Australia were developing commerce with the mother country, and the business of the *Rattlesnake* was to survey the waters round about the Torres Straits, that the passage towards India on the homeward trip might be made safer. Incidentally the vessel was to land a treasure of £50,000 at the Cape of Good Hope, and another of £15,000 at the Mauritius. The Admiralty Commissioners left full powers to Captain Stanley to carry out the details of his mission according to his own judgment, but he was solemnly warned upon two points. Many very unfortunate casualties had occurred when sailors came in contact with the little-known savages of the southern seas, and the Admiralty instructed him as follows:

"In stretching off from the Barrier Reefs to the eastward, in order to explore the safety of the sea

intervening between them and Louisiade and New Guinea, you will have occasion to approach these shores, in which case you must constantly be on your guard against the treacherous disposition of their inhabitants. All barter for refreshments must be conducted under the eye of an officer, and every pains be taken to avoid giving any just cause of offence to their prejudices, especially with respect to their women."

The second warning concerned grave international matters. European politics were in the unsettled condition which, after the illusive international courtesies of the Great Exhibition of 1851, ended in the Crimean War, and it was feared that in the event of hostilities breaking out, the zeal of the officers for their country might tempt them to transcend their peaceful occupation. The instructions with regard to this ran as follows:

"In the event of this country being involved in hostilities during your absence, you will take care never to be surprised; but you are to refrain from any act of aggression towards the vessels or settlements of any nation with which we may be at war, as expeditions employed on behalf of discovery and science have always been considered by all civilised communities as acting under a general safeguard."

The great scientific expeditions sent out in recent times by the governments of Britain, Germany, and the United States, were fitted with every convenience for the staff of naturalists, and the luxuries and comforts of civilisation attended them round the world. The late Professor Moseley, for instance, who was a naturalist on the English *Challenger* expedition, told the present writer of a pleasant way in which a peculiarity of the deep sea was made to pay toll to the comfort of those on board ship. The great ocean depths all over the world, under the burning skies of the tropics, or below the arctic ice-fields, are extremely cold, the water at the bottom always being only a few degrees above freezing-point. When the dredge brought up a sample of the abysmal mud at a convenient

time, it was used to ice the wine for the officers' mess. There was, however, no cooled champagne for Huxley.

"Life on board Her Majesty's ships in those days," he writes, "was a very different affair from what it is now, and ours was exceptionally rough, as we were often many months without receiving letters or seeing any civilised people but ourselves. In exchange, we had the interest of being about the latest voyagers, I suppose, to whom it could be possible to meet with people who knew nothing of fire-arms—as we did on the south coast of New Guinea—and of making acquaintances with a variety of interesting savage and semi-civilised people. But apart from experience of this kind, and the opportunities offered for scientific work, to me personally the cruise was extremely valuable. It was good for me to live under sharp discipline: to be down on the realities of existence by living on bare necessities; to find out how extremely well worth living life seemed to be when one woke up from a night's rest on a hard plank with the sky for canopy, and cocoa and weevilly biscuit the sole prospect for breakfast; and more especially to learn to work for the sake of what I got for myself out of it, even if it all went to the bottom and I myself along with it. My brother officers were as good fellows as sailors ought to be, and generally are, but naturally they neither knew nor cared anything about my pursuits, nor understood why I should be so zealous in pursuit of the objects which my friends the middies christened 'Buffons,' after the title conspicuous on a volume of the *Suites à Buffon* which stood on my shelf in the chart-room."

Huxley was only the surgeon on board the *Rattlesnake*, and his pursuit of natural history was his own affair. There was a special naturalist appointed to the expedition, no doubt chosen because four years earlier, as assistant to Professor Jukes, he had been attached as naturalist to the expedition of the *Fly* in the same waters. His name was John MacGillivray, and he was the son of an exceedingly able naturalist whose reputation has been overshadowed by the greater names of the middle century. William MacGillivray, the father, sometime Professor at the University of Aberdeen, was one of those driven by an almost

instinctive desire to the study of nature. In his youth, when he was a poor lad, desiring to see as much as possible of his native land, and above all to visit the great museums and libraries of the south, he walked from Aberdeen to London with no luggage but a copy of Smith's *Flora Britannica*. He was an ardent botanist, a collector of insects and molluscs, and one of the pioneers in the anatomy of birds. There are many curious allusions in his writings which seem to shew that he too was beginning to doubt the fixity of species, and to guess at the struggle for existence and survival of the fittest which the great Darwin was the first to make a part of the knowledge of the world. It must be confessed that his son John, the companion of Huxley, had little of his father's ability. He was three years older than Huxley, and broke off his medical course at the University of Edinburgh to sail in the *Fly*. After the return of the *Rattlesnake*, he was appointed in 1852 as naturalist to H.M.S. *Herald*, then starting under Captain Denham for surveying work round the shores of South America. He left that ship at Sydney, and after many years' wandering about the southern seas, accounts of which he communicated from time to time to Sydney newspapers, he died in 1867. He was a zealous collector of plants and animals, but apparently cared little for the study of his captures, either in life, in relation to their surroundings, like Darwin, or for the structure of their bodies, like Huxley. On the other hand, MacGillivray paid great attention to native languages, and collected vocabularies of some value. To him was entrusted the task of writing an account of the voyage, and it is from his rather dull pages, brightened by illustrations from Huxley's sketches, that the incidents of the voyage are taken. The references to Huxley in the narrative are slight, and seem to shew that no great intimacy existed between the two young men, the one a naturalist by profession, the other as yet a surgeon, but more devoted to natural history than the naturalist. Such references as occur relate to

Huxley's constant occupations on shore, sketching natives and their dwellings, and his apparatus on board for trawling, dredging, and dissecting.

The voyage out was uneventful. The ship touched at Madeira and at Rio de Janeiro, and then crossed the South Atlantic to Simon's Town at the Cape of Good Hope, where the first quantity of treasure was to be landed. There they found the colony distressed by the long continuance of the Kaffir war. Prices for everything were extortionate, and the colonists had no mind for any affairs than their own, so after a short stay the voyagers were glad to set out for the Mauritius. That island, although in the possession of Britain, still retained a strong impress of its French occupation, and the travellers were interested by the mixture of population inhabiting it.*

"Passing through the closely packed lines of shipping, and landing as a stranger at Port Louis, perhaps the first thing to engage attention is the strange mixture of nations—representatives, he might at first be inclined to imagine, of half the countries of the earth. He stares at a coolie from Madras with a breech-cloth and a soldier's jacket, or a stately bearded Moor striking a bargain with a Parsee merchant. A Chinaman with two bundles slung on a bamboo hurries past, jostling a group of young Creole exquisites smoking their cheroots at a corner, and talking of last night's Norma, or the programme of the evening's performance at the Hippodrome in the Champ de Mars. His eye next catches a couple of sailors reeling out of a grogshop, to the amusement of a group of laughing negresses, in white muslin dresses of the latest Parisian fashion, contrasting strongly with a modestly attired Cingalese woman, and an Indian ayah with her young charge. Amidst all this, the French language prevails; and everything more or less pertains of the French character, and an Englishman can scarcely believe that he is in one of the colonies of his own country."

From Mauritius they proceeded to the English-

* *Narrative of the Voyage of H.M.S. "Rattlesnake,"* by John MacGillivray, F.R.G.S. 2 vols. T. W. Boone, London, 1852.

looking colony of Tasmania, and after a few days set out for Sydney, arriving there on July 16th. The surveying officers had tedious work to do there, and Huxley stayed in Sydney for three months. Then, and in the course of three other prolonged stays in that town during the expedition, Huxley entered into the society of the town and became a general favourite. It was there that he met the lady who was to become his wife. There, also, he availed himself of the opportunity of consulting a wider range of scientific literature than was available on board ship, for Sydney possessed some good libraries. He was able to compare his own dissections and drawings with work that had already been published, and to prepare some of his own results for transmission to the learned societies of London.

On October 11th the *Rattlesnake* sailed northwards to begin the real work of the expedition. The great island of New Guinea, lying to the north of Australia, is separated from it only by the comparatively narrow Torres Straits. Through these lies the natural route for the commerce between Australia and the Northern Hemisphere. The eastward prolongation of New Guinea, and the coast of Queensland, enclose between them a great tropical sea which gradually converges to the Straits. The waters are tempestuous, and the navigation is made more dangerous by the thousands of coral islands and coral reefs that stud the ocean. Following the shoreline of Queensland, at a distance of from ten to one hundred and fifty miles, and stretching for twelve hundred and fifty miles, is the Great Barrier Reef of Australia, one of the wonders of the world. The shelving floor of the ocean rises nearly to the surface along this line, and vast colonies of coral-building creatures have formed their reefs up to the water's edge along the ridge. The turbulent waves scouring over this living mass have carved and moulded it into millions of fantastic islands, sometimes heaping detached masses of dead debris high above the surface of the water. At low tide the most wonderful

fields of the animal flowers of the sea are exposed. Some of these form branching systems of hard skeletons like stony trees, the soft, brightly coloured animals dotted over the stems like buds. Others build solid masses; others, again, rounded skull-like boulders, or elevations like toadstools. The colours of the skeletons and the animals are vivid scarlets and purples and greens. Sea-anemones, shell-fish, and starfish of the most vivid hues are as abundant as the corals. Brilliant fish dart through the blossoms of the marine gardens, and sea-birds scream and wheel in the air. The whole region is a paradise for the naturalist. Along the seaward side of the reef the great ocean surges and thunders perpetually. Between it and the shore the quiet channel glows under the tropical skies. It was amid such scenes as these that the *Rattlesnake* moved for nearly four years in the slow work of taking soundings, fixing the exact position of channels through the outer reef by slow triangular measurements, and generally preparing for the safety of the commerce of all nations. The ship went first up to Port Curtis in Brisbane, and fetched back to Sydney. Its next trip was south to the strait between Tasmania and Australia, then back to Sydney, returning along the Barrier Reef right up to the Torres Straits. After work there, it again visited Sydney, and then set out for the Louisiade Archipelago, which stretches through the coral sea south-eastward from New Guinea; then again to the Australian shores of the Torres Straits, and finally arrived in Sydney in March, 1850, where the Captain suddenly died, and the ship was ordered to return to England.

Throughout the voyage MacGillivray and Huxley busied themselves with collecting animals on sea and on shore. MacGillivray seems to have taken for his share of the spoil chiefly such animals as provided shells or skins or skeletons suitable for handing over to museums. Huxley occupied himself incessantly with dissecting tools and with the microscope, with results to be described in a later

chapter. The better-equipped expeditions of modern times were provided with elaborate appliances for bringing up samples of living creatures from all depths of the floor of the ocean, and with complicated towing nets for securing the floating creatures of the surface of the seas. The *Rattlesnake* naturalists had to carry out their work with simple apparatus devised by themselves. At an early period of the voyage attempts were made to take deep soundings, but no bottom was reached at a depth of two thousand four hundred fathoms, and their later work was confined to surface animals or to inshore dredging in shallow waters. They began near Rio.

"None of the ship's boats could be spared, so I [MacGillivray] hired one pulled by four negro slaves who, although strong, active fellows, had great objections to straining their backs at the oar, when the dredge was down. No sieve having been supplied, we were obliged to sift the contents of the dredge through our hands—a tedious and superficial mode of examination. Two days after, Mr. Huxley and I set to work in Botafogo Bay, provided with a wire-gauze meat-cover and a curious machine for cleaning rice; these answered capitally as substitutes for sieves, and enabled us, by a thorough examination of the contents of the dredge, to detect some forty-five species of Mollusca and Radiata, some of which were new to science."

By "new to science" MacGillivray meant no more than that the particular genera and species had not been captured before. Huxley, by his anatomical work, shewed many of the most familiar creatures in a light "new to science," by revealing their true structure and relationships.

The towing net repeatedly produced a rich harvest. It was constructed by themselves, and consisted of a bag made of the bunting used for flags, two feet deep, the mouth being sewn round a wooden hoop fourteen inches in diameter; three pieces of cord, a foot and a half long, were secured to the hoop at equal intervals and had their ends tied together. This net was towed behind the ship

by a stout cord. The water passed through the meshes of the cloth and left behind in the pocket any small floating animals.

Excursions ashore to the little savage islands or to the mainland were a source of constant interest, and the acquaintance Huxley thus gained with many of the very low savages of Australia and New Guinea prepared his mind for the revolutionary doctrine of descent which he embraced a few years later. At the present time, there are probably very few parts of the earth where there are yet to be found savages unaltered by civilisation. Some of the low races with which Huxley came in contact are now extinct. All the survivors have come in contact with white races, and their habits and customs have been altered. Before long the total extinction of these lower races is to be expected, and there will then be left an enormous gap between the lower animals and the dominant, aggressive, yellow and white races which are spreading over the earth and making the lower races perish before them, as the smaller but more cunning European rat has exterminated the native brown rat of Australia. In their various excursions upon the Australian mainland Huxley and his companions had no trouble of any kind with the natives. These were at first suspicious of the doings of the white men, and their total ignorance of the use of fire-arms tempted them to rashness; but a few friendly gifts, and the exercise of tact in negotiating exchanges with them, made all the encounters pass off pleasantly. On the other hand, in the Louisiade Archipelago, where the savages were of a higher type, difficulties constantly occurred. On one occasion, in a bay on the south side of Joannet Island the party was attacked.

"In the grey of the morning the look-outs reported the approach of three canoes with about ten men in each. On two or three persons showing themselves in the bow of the pinnace, in front of the rain awning, the natives ceased paddling, as if baulked in their design of surprising the large boat; but, after a short consultation, they came alongside in their usual noisy

manner. After a stay of about five minutes only they pushed off to the galley, and some more sham bartering was attempted, but they had nothing to give in exchange for the wares they so much coveted. In a short time the rudeness and overbearing insolence of the natives had risen to a pitch which left no doubt of their hostile intentions. The anchor was got up, when some of the blacks seized the painter, and others, in trying to capsize the boat, brought the gunwale down to the water's edge, at the same time grappling with the men to pull them out, and dragging the galley inshore towards the shoalwater. The bowman, with the anchor in his hand, was struck on the head with a stone-headed axe. The blow was repeated, but fortunately took effect only on the wash-streak. Another of the crew was struck at with a similar weapon, but warded off the blow, although held fast by one arm, when, just as the savage was making another stroke, Lientenant Dayman, who up till now had exercised the utmost forbearance, fired at him with a musket. The man did not drop, although wounded in the thigh. But even this, unquestionably their first experience of firearms, did not intimidate the natives, one of whom, standing on a block of coral, threw a spear which passed across the breast of one of the boat's crew and lodged in the bend of one arm, opening a vein. They raised a loud shout when the spear was seen to take effect, and threw several others which missed. Lieutenant Simpson, who had been watching what was going on, then fired from the pinnace with buckshot and struck them, when, finding that the large boat, though at anchor, could assist the smaller one, the canoes were paddled inshore in great haste and confusion. Some more musket shots were fired, and the galley went in chase endeavouring to turn the canoes, so as to bring them under fire of the pinnace's twelve-pounder howitzer, which was speedily mounted and fired. The shot either struck one of the canoes or went within a few inches of the mark, on which the natives instantly jumped overboard into the shallow water, making for the mangroves, which they succeeded in reaching, dragging their canoes with them. Two rounds of grape-shot crashing through the branches dispersed the party, but afterwards they moved two of the canoes out of sight. The remaining one was brought out after breakfast by the galley under cover of the pinnace, and was towed off to some distance. The paddles having been taken out and the spears broken and left in her, she was let go to drift down toward a village whence the attacking party were supposed to have come. Some blood in this

canoe, although not the one most aimed at, shewed that the firing had not been ineffective. This act of deliberate treachery was perpetrated by persons who had always been well treated by us, for several of the natives present were recognised as having been alongside the ship in Coral Haven. This, their first act of positive hostility, affords, I think, conclusive evidence of the savage disposition of the natives of this part of the Louisiade Archipelago when incited by the hope of plunder, and shews that no confidence should ever be reposed in them, unless, perhaps, in the presence of a numerically superior force, or in the close vicinity of a ship. At the same time, the boldness of these savages in attacking, with thirty men in three canoes, two boats known to contain at least twenty persons—even in the hopes of taking them by surprise—and in not being at once driven off upon feeling the novel and deadly effects of firearms, shews no little amount of bravery."

On their last visit to Cape York, in the extreme north of Australia, the party had the remarkable experience of rescuing a white woman from captivity among the natives.

"In the afternoon some of our people on shore were surprised to see a young white woman come up to claim their protection from a party of natives from whom she had recently made her escape, and who she thought would otherwise bring her back. Of course she received every attention, and was taken on board the ship by the first boat, when she told her story which is briefly as follows: Her name is Barbara Thomson. She was born at Aberdeen in Scotland, and, along with her parents, emigrated to New South Wales. About four years and a half ago she left Moreton Bay with her husband in a small cutter, called the *America*, of which he was the owner, for the purpose of picking up some of the oil from the wreck of a whaler, lost on the Bampton shoal, to which place one of her late crew undertook to guide them; their ultimate intention was to go on to Port Essington. The man who acted as pilot was unable to find the wreck, and after much quarrelling on board in consequence, and the loss of two men by drowning and of another who was left on a small uninhabited island, they made their way up to the Torres Straits, where, during a gale of wind, their vessel struck upon a reef on the eastern Prince of Wales Island. The two remaining men were lost in attempting to swim on

shore through the surf, but the woman was afterwards rescued by a party of natives on a turtling excursion, who, when the gale subsided, swam on board and supported her on shore between two of their number. One of these blacks, Boroto by name, took possession of the woman as his share of the plunder; she was compelled to live with him, but was well treated by all the men, although many of the women, jealous of the attention shewn her, for a long time evinced anything but kindness. A curious circumstance secured for her the protection of one of the principal men of the tribe. This person, acting upon the belief, universal throughout Australia and the islands of the Torres Strait, so far as hitherto known, that white people are the ghosts of the aborigines, fancied that in the stranger he recognised a long-lost daughter, and at once admitted her into the relationship which he thought had formerly subsisted between them. She was immediately acknowledged by the whole tribe as one of themselves, thus securing an extensive connection in relatives of all denominations. The headquarters of the tribe being on an island which all vessels passing through the Torres Strait from the eastward must approach within two or there miles, she had the mortification of seeing from twenty to thirty or more ships go through every summer without anchoring in the neighbourhood, so as to afford the slightest opportunity of making her escape. Last year she heard of our two vessels being at Cape York, only twenty miles distant from some of the tribe who had communicated with us and had been well treated, but they would not take her over and watched her even more narrowly than before. On our second and present visit, however, which the Cape York people immediately announced by smoke signals to their friends, she was successful in persuading some of her more immediate friends to bring her across to the mainland within a short distance of where the vessels lay. The blacks were credulous enough to believe that as she had been so long with them and had been so well treated, she did not intend to leave them—only 'she felt a strong desire to see the white people once more and shake hands with them': adding that she would be certain to purchase some axes, knives, tobacco, and other much-prized articles."

Although the external adventures of the *Rattlesnake* party were less varied and exciting than might have been expected in a voyage of four

years in the tropic seas and among barbarian tribes, the mental adventures through which Huxley passed in the time must have been of the most surprising kind. It was a four-years' course in the great university of nature, and when he had finished it he was no longer a mere student, capricious and unsettled in his mental tastes and inclinations, but had set his face steadily towards his future life-work. It is interesting to compare the importance in Huxley's life of the *Rattlesnake* voyage with the importance in Darwin's life of the voyage on the *Beagle* undertaken some fifteen years earlier. Huxley, when he started, was a young surgeon with a taste of a vague kind for dissecting and for drawing the peculiarities of structure of different animals revealed by the knife and the microscope. Day after day, month after month, year after year, in the abundant leisure his slight professional duties left him, he dissected and drew animal after animal, as he got them from the dredge or tow-net, or from the surface of the coral reefs. He was never in any sense of the word a collecting naturalist. Even in later life he found it difficult to take an interest in what is usually known as natural history, and walking once with Hooker in the Rhone Valley, when at every footstep grasshoppers leapt into the air, displaying their variously coloured wings, he said, "I would give anything to be as interested in them as you are." The identification and naming of species interested him little. What he cared for was, he tells us, "the architectural and engineering part of the business: the working out of the wonderful unity of plan in the thousands and thousands of diverse living constructions, and the modifications of similar apparatuses to serve different ends." And so, on the *Rattlesnake*, and in his work in continuation of the *Rattlesnake* investigations—which occupied most of his time for a few years after his return to London—there was gradually growing up in his mind a dim conception of the animal kingdom as a group of creatures, not built on half a dozen or more separate plans or types, each unconnected with the other,

but as a varied set of modifications of a single type.

When Darwin set out on the *Beagle*, unlike Huxley, he was an enthusiastic collecting naturalist. He had wandered from county to county in England adding new specimens to his collections of butterflies and beetles. As the *Beagle* went round the world visiting remote islands, far from land in the centre of the waters, archipelagoes of islands crowding together, islands hugging the shore of continents, and the great continents of the old and new worlds, he continued to collect and to classify. Gradually the resemblances and differences between the creatures inhabiting different parts of the earth began to strike him as exhibiting an orderly plan. He saw that under apparently the same conditions of food and temperature and moisture, in different parts of the world the genera and species were different, and that they were most alike in regions between which there was the most recent chance of migrations having taken place. In the quietness of England, while Huxley was on the *Rattlesnake*, Darwin was slowly working towards the explanation of all he had seen : towards the conception that animals and plants had spread slowly from common centres, becoming more and more different from each other as they spread. He realised on his voyage that species had come into existence by descent with modification, and before long he was to publish to the world in the *Origin of Species* a vast and convincing bulk of evidence as to the actual fact of a common descent for all the different existing organisms, and, in his theory of natural selection, a reasonable explanation of how the fact of evolution had come about. Darwin's greatest ally in bringing the new idea before the world was Huxley, and Huxley was teaching himself the absolute unity of the living world. The two men were dissimilar in tastes and temperament, and they were at work on quite different sides of nature. When the time came, Huxley, with his commanding knowledge of the structure of animals, was ready

to support Darwin and to illustrate and amplify his arguments by a thousand anatomical proofs. It is a curious and dramatic coincidence to realise that both men learned their very different lessons under very similar circumstances in the tropical seas of the Southern Hemisphere.

CHAPTER III

FLOATING CREATURES OF THE SEA

AS the *Rattlesnake* sailed through the tropical seas Huxley came in contact with the peculiar and interesting inhabitants of the surface of the sea, known now to naturalists as pelagic life or "plankton." Although a poet has spoken of the "unvintageable sea," all parts of the ocean surface teem with life. Sometimes, as in high latitudes, the cold is so great that only the simplest microscopic forms are able to maintain existence. In the tropics, animals and plants are abundant, and sometimes by their numbers colour great areas of water; or, as in the drift of the Gulf Stream, make a tangle of animal and plant life through which a boat travels only with difficulty. The basis of the food-supply of this vast and hungry floating life is, as on land, vegetable life; for plants are the only creatures capable of building up food from the gases of the air and the simple chemical salts found dissolved in water. Occasionally, in shallow or warm seas, marine floating plants, large and visible like the sea-weeds of the coast, form the floating masses known as Sargasso seas; more often the plants are minute, microscopic specks visible only when a drop of water is placed under the microscope, but occurring in incredible numbers, and, like the green vegetation of the earth, forming the ultimate food-supply of all the living things around them. Innumerable animals, great and small, live on the plants or upon their fellows, and, however far he may be from land, the naturalist has always abundant material got by his daily use

of the tow-net. This drifting population floats at the mercy of the waves. Most of the animals are delicate, transparent creatures, their transparency helping to protect them from the attacks of hungry fellows. Nerves, muscles, skin, and the organs generally are clear, pale, and hardly visible. Such structures as the liver, the reproductive organs, and the stomach, which cannot easily become transparent, are grouped together into small knots, coloured brown like little masses of sea-weed. Other floating creatures are vividly coloured, but the hues are bright blues and greens closely similar to the sparkling tints of sea-water in sunlight. The different members of this marine flotsam frequently rise and fall periodically: some of them sinking by day to escape the light, others rising only by day; others, again, appearing on the surface in spring, keeping deep down in winter. Perhaps the majority of them are phosphorescent, sometimes shining by their own light, sometimes borrowing a glory from innumerable phosphorescent bacteria with which they are infested. Nearly every class of the animal kingdom contributes members to this strange population. The young forms of many fish, as for instance of conger, flying gurnards, and some flatfish, are pelagic and have colourless blood, and pale, transparent, gelatinous or cartilaginous skeletons. The tadpole-like stages of the sea-squirts, which in adult life are to be found attached to rocks like weeds, drift about in the surface waters until their time comes for settling down in life. Many other Ascidians pass their whole life as pelagic creatures. A few molluscs, many kinds of worms, echinoderms, and their allies, crab and lobster-like creatures in innumerable different stages of development, are to be found there, while unnumbered polyps and jelly-fish are always present. It would be difficult to imagine a better training for the naturalist than to spend years, as Huxley did, working at this varied assortment of living creatures. Huxley declared that the difficulties of examining such flimsy creatures had been exaggerated.

"At least, with a good light and a good microscope, with the ship tolerably steady, I never failed in procuring all the information I required. The great matter is to obtain a good successive supply of specimens, as the more delicate oceanic species are usually unfit for examination within a few hours after they are taken."

Day after day, as the *Rattlesnake* crept from island to island, Huxley examined the animals brought up by his tow-net. He made endless dissections, and gradually accumulated a large portfolio of drawings. Much of the time he passed at Sydney was spent in libraries and museums, comparing his own observations with the recorded observations of earlier workers, and receiving from the combination of his own work and the work of others new ideas for his future investigations. It was all entirely a labour of love; it lay outside the professional duties by which he made his living, and for a long time it seemed as if he was not even to gain reputation by the discoveries he knew himself to be making. He writes in his autobiography:

"During the four years of our absence, I sent home communication after communication to the 'Linnæan' Society, with the same result as that obtained by Noah when he sent the raven out of his ark. Tired at last of hearing nothing about them, I determined to do or die, and in 1849 I drew up a more elaborate paper and forwarded it to the Royal Society. This was my dove, if I had only known it; but owing to the movements of the ship I heard nothing of that either until my return to England in the latter end of the year 1850, when I found that it was printed and published, and that a huge packet of separate copies awaited me. When I hear some of my young friends complain of want of sympathy and encouragement, I am inclined to think that my naval life was not the least valuable part of my education."

This first successful paper was a memoir *On the Anatomy and the Affinities of the Family of Medusæ*, and was sent at Captain Stanley's suggestion to that officer's father, the Bishop of Norwich, who communicated it to the Royal Society. It is a curious circumstance that Huxley,

who afterwards met with so virulent opposition from bishops, owed his first public success to one of them. Professor Sir Michael Foster wrote of this period in Huxley's life :

" The career of many a successful man has shewn that obstacles often prove the mother of endeavour, and never was this lesson clearer than in the case of Huxley. Working amidst a host of difficulties, in want of room, in want of light, seeking to unravel the intricacies of minute structure with a microscope lashed to secure steadiness, cramped within a tiny cabin, jostled by the tumult of a crowded ship's life, with the scantiest supply of books of reference, with no one at hand of whom he could take counsel on the problems opening up before him, he gathered for himself during these four years a large mass of accurate, important, and in most cases novel, observations, and illustrated them with skilful, pertinent drawings. Even his intellectual solitude had its good effects: it drove him to ponder over the new facts which came before him, and all his observations were made alive with scientific thought."

Afterwards, in England, he received the Royal Medal of the Royal Society for this memoir on Medusæ, sharing this supreme distinction of scientific England with men so illustrious as Joule, the discoverer of the relation between force and heat, Stokes, the great investigator of optical physics, and Humboldt, the traveller, all of whom received medals in the same year. In making the presentation to Huxley, the Earl of Rosse, then President of the Royal Society, declared :

" In those papers you have for the first time fully developed their structure (that of the Medusæ), and laid the foundation of a rational theory for their classification. In your second paper, on the anatomy of Salpa and Pyrosoma, the phenomena have received the most ingenious and elaborate elucidations, and have given rise to a process of reasoning, the results of which can scarcely yet be anticipated, but must bear in a very important degree upon some of the most abstruse points of what may be called transcendental physiology."

Many reasons make it difficult for us to realise, now, the singular novelty and importance of

Huxley's memoir on the Medusæ. The first is a reason which often prevents great discoveries in almost every subject from receiving in after years their due respect. The years that have passed since 1850 have seen not only the most amazing progress in our knowledge of comparative anatomy, but almost a revolution in the methods of studying it. Huxley's work has been incorporated in the very body of science. A large number of later investigators have advanced upon the lines he laid down; and just as the superstructures of a great building conceal the foundations, so later anatomical work, although it has only amplified and extended Huxley's discoveries, has made them seem less striking to the modern reader. The present writer, for instance, learned all that he knows of anatomy after 1886, and until he turned to it for the purpose of this volume he had never referred to Huxley's original paper. When he did so, he found from beginning to end nothing that was new to him, nothing that was strange: all the ideas in the memoir had passed into the currency of knowledge and he had been taught them as fundamental facts. It was only when he turned to the text-books of anatomy and natural history current in Huxley's time that he was able to realise how the conclusions of the young ship-surgeon struck the Fellows and President of the Royal Society as luminous and revolutionary ideas.

In the first half of the century, a conception of the animal kingdom prevailed which was entirely different from our modern ideas. We believe now that all animals are bound together by the bond of a common descent, and we seek in anatomy a clue to the degrees of relationship existing among the different animals we know. We regard the animal kingdom as a thicket of branches all springing from a common root. Some of these spring straight up from the common root unconnected with their fellows. Others branch repeatedly, and all the branches of the same stem have features in common. What we see in the living world is only the surface of the thicket, the tops of the twigs; and it

is by examination of the structure of this surface that we reconstruct in imagination the whole system of branches, and know that certain twigs, from their likeness, meet each other a little way down; that others are connected only very deep down, and that others, again, spring free almost from the beginning. The fossils from beds of rock of different geological ages give us incomplete views of the surface of the thicket of life, as it was in earlier times. These views we have of the past aspects of the animal kingdom are always much more incomplete than our knowledge of the existing aspect; partly because many animals, from the softness of their bodies, have left either no fossil remains at all, or only very imperfect casts of the external surfaces of their bodies; and partly because the turning of any animal into a fossil, and its subsequent discovery by a geologist, are occasional accidents; but, although the evidence is much less perfect than we could wish, there is enough of it to convince anatomists that existing animals are all in definite blood-relationship to each other, and to make them, in the investigation of any new animal, study its anatomy with the definite view of finding out its place in the family tree of the living world.

When Huxley made his first discoveries, entirely different ideas prevailed. The animal kingdom was supposed to offer a series of types, of moulds, into which the Creator had cast the substance of life at the beginning of the world. These types were independent of each other, and had been so since their creation. Anatomists were concerned chiefly with systematic work, with detecting and recording the slight differences that existed among the numbers of animals grouped around each type. No attempt was made to see connection between type and type, for where these had been separately created there was nothing to connect them except possibly some idea in the mind of the Creator. This apparently barren attitude to nature was stronger in men's minds because it had inspired the colossal achievements of Cuvier, a genius who,

under whatever misconceptions he had worked, would have added greatly to knowledge. As we have seen in the first chapter, Huxley, through Wharton Jones, and through his own reading, had been brought under the more modern German thought of Johannes Müller and von Baer. He had learned to study the problems of living nature in the spirit of a physicist making investigations into dead nature. In the anatomy of animals, as in the structure of rocks and crystals, there were to be sought out "laws of growth" and shaping and moulding influences which accounted for the form of the structures. To use the technical term, he was a morphologist: one who studied the architecture of animals not merely in a spirit of admiring wonder, but with the definite idea of finding out the guiding principles which had determined these shapes.

Not only was the prevailing method of investigation faulty, but actual knowledge of a large part of the animal kingdom was extremely limited. In the minds of most zoologists the animal kingdom was divided into two great groups: the vertebrates and invertebrates. The vertebrate, or back-boned, animals were well known; they are all built more or less on the type of man; and human anatomists, who indeed made up the greater number of all anatomists, using their exact knowledge of the human body, had studied many other vertebrates with minute care, and, from man to fishes, had arranged living vertebrates very much in the modern order. But the invertebrates were a vague and ill-assorted heap of animals. It was not recognised that among them there were many series of different grades of ascending complexity, and there was no well-known form to serve as a standard of comparison for all the others in the fashion that the body of man served as a standard of comparison for all vertebrates. Here and there, a few salient types such as insects and snails had been picked out, but knowledge of them helped little with many of the invertebrates. The great Linnæus had divided the animal kingdom into four groups

of vertebrates: mammals, birds, reptiles, and fishes, but for the invertebrates he had done no more than to pick out the insects as one group and to call everything else "Vermes" or worms. The insects included all creatures possessed of an external skeleton or hard skin divided into jointed segments, and included forms so different as insects, spiders, crabs, and lobsters. But Vermes included all the members of the animal kingdom that were neither vertebrates nor insects. Cuvier advanced a little. He got rid of the comprehensive title Vermes—the label of the rubbish-heap of zoologists. He divided animals into four great sub-kingdoms: Vertebrata, Mollusca, Articulata, Radiata. These names, however, covered only very superficial resemblances among the animals designated by them. The word *Mollusca* only meant that the creatures grouped together had soft bodies, unsupported by internal or external articulated skeletons; and this character, or, rather, absence of character, was applied alike to many totally dissimilar creatures. The term *Articulata* included not only Linnæus's insects but a number of soft-skinned, apparently jointed, worm-like animals such as the leech and earthworm. Lastly, the name *Radiata* meant no more than that the organs of the creatures so designated were more or less disposed around a centre, as the sepals and petals of a flower are grouped around the central pistil; and it included animals so different as the starfish and sea-anemones and jelly-fish. The names used in the classification were not only loosely applied but were based on the most superficial observation, and took no account of the intimate structure of the tissues and organs of the animals. With slight modifications, due to individual taste or special knowledge of small groups, later writers had followed Linnæus and Cuvier.

It was with a view of the animal kingdom not much clearer than this that Huxley began his work on the Medusæ or jelly-fish of the tropic seas. He began to study them simply because they were among the most abundant of the animals that

could be obtained from the ship. He made many dissections and drawings, and, above all, studied their minute anatomy with the microscope. They were all placed among Cuvier's *Radiata*, but, as Huxley said in the first line of his memoir:

"Perhaps no class of animals has been investigated with so little satisfactory and comprehensive result, and this not for the want of patience and ability on the part of the observers, but rather because they have contented themselves with stating matters of detail concerning particular genera and species, instead of giving broad and general views of the whole class, considered as organised upon a given type, and inquiring into its relations with other families."

He found that fully developed Medusæ consisted each of a disc with tentacles and vesicular bodies at the margins, a stomach, and canals proceeding from it, and generative organs. He traced this simple common structure through the complications and modifications in which it appeared in the different groups of Medusæ, in all this work bringing out the prevailing features of the anatomy in contrast to the individual peculiarities. He shewed that microscopically all the complicated systems of canals and organs were composed of two "foundation-membranes," two thin webs of cells, one of which formed the outermost layer of the body, while the inner formed the lining of the stomach and canals in the thinner parts of the body, such as the edges of the umbrella-like disc, and towards the ends of the tentacles. These thin webs formed practically all the body. In the thicker parts there was interposed between them an almost structureless layer of jelly, placed like padding between the lining and the cloth of a coat. He shewed that blood-vessels and blood were absent, in which he has been confirmed by all other observers. He declared more doubtfully against the existence of a special nervous system, and it was not until long after, when the methods of microscopic investigation were much more perfect, that the delicate nerve-cells and nerve-fibres, which we now know to exist, were discovered.

Having thus shewn the peculiar organisation of the group he turned to seek out its allies among other families. The Medusæ consisted essentially of two membranes inclosing a variously shaped cavity, inasmuch as all its organs were so composed. The generative organs were external, being variously developed processes of the two membranes. The peculiar organs called thread-cells—poisoned darts by the discharge of which prey could be paralysed—were universally present. What other families presented these peculiarities?

There are to be found abundantly in sea-water, and less frequently in fresh water, innumerable forms of animal life called Zoophytes or animal plants because they occur as encrusting masses like lichens, or branched forests like moss, on the surface of stones and shells. A common habit gave this set of creatures their common name; but, although they were grouped together, there was no greater affinity among them than there is racial affinity among people who clothe themselves for an evening party in the same conventional dress. Huxley examined a large number of these, and picked out from them two great families, the Hydroid and Sertularian polyps, which each consist of colonies of creatures very much like the little fresh-water hydra. He shewed that the tubular body of these and the ring of tentacles surrounding the mouth were composed of the same two foundation-membranes of which all the organs of Medusæ are composed. He found in them the poisoned arrows or thread cells of the Medusæ, and the same external position of the reproductive organs. And, lastly, he separated from all other creatures, and associated with his new group, some of the strangest and most beautiful animals of the tropic seas, known to science as the Physophoridæ and the Diphyidæ. The best-known of these is the "Portuguese man-of-war," the body of which consists of a large pear-shaped vesicle which floats on the water like a bladder. From the lower part of this depend into the water large and small nutritive branches, each ending in a mouth sur-

rounded by a circle of waving tentacles armed with batteries of thread-cells, while another set of hanging protrusions bear the grape-like reproductive organs. On the upper surface of the bladder is fixed a purple sail of the most brilliant colour, by which the floating creature is blown through the water. This, like its equally wonderful allies, Huxley shewed to be a complicated colony of hydra-like creatures, each part being composed of two membranes, and therefore essentially similar to Medusæ. Thus, by a great piece of constructive work, an assemblage of animals was gathered into a new group and shewn to be organised upon a simple and uniform plan, even in the most complex and aberrant forms, reducible to the same type. The group, and Huxley's conception of its structure, are now accepted by anatomists, and have made one of the corner-stones of our modern idea of the arrangement of the animal kingdom. With the exception of sponges, concerning the exact relations of which there is still dispute, and of a few sets of parasitic and possibly degenerate creatures, all animals with multicellular bodies, from the simple fresh-water hydra up to man, are divided into two great groups. The structure of the simpler of these groups is exactly what Huxley found to be of importance in the Medusæ. The body wall, from which all the organs protrude, consists merely of a web of cells arranged in two sheets or membranes, and the single cavity consists of a central stomach, surrounded by these membranes, the cavity remaining simple or giving rise to a number of branching canals. The members of this great division of the animal kingdom are the creatures which Huxley selected and placed together, with the addition of the sea-anemones and the medusa-like Ctenophora, which, indeed, he mentioned in his memoir as being related to the others, although he reserved fuller consideration for a future occasion. This group is now called the Cœlentera, the name implying that the creatures are simply hollow stomachs, and it is contrasted in the strongest

way with the group Cœlomata, in which are placed all the higher animals, from the simplest worm up to man; animals displaying, in addition to the two foundation-membranes of the Cœlentera, also a third foundation-membrane, and in which, in addition to the simple stomach cavity with its offshoots, there is a true body-cavity or cœlom, and usually a set of spaces and channels containing a blood-fluid. The older method of naming groups of animals after some obvious superficial character lingered on for some years in text-books and treatises, but in this memoir the young ship-surgeon had replaced it by the modern scientific method of grouping animals together only because of real identity of structure.

There is yet left to be noticed perhaps the most wonderful of all the ideas in this first memoir by Huxley. In the course of describing the two foundation-membranes of the Medusæ he remarks:

"It is curious to remark, that throughout, the outer and inner membranes appear to bear the same physiological relation to one another as do the serous and mucous layers of the germ: the outer becoming developed into the muscular system, and giving rise to the organs of offence and defence; the inner on the other hand appearing to be more closely subservient to the purposes of nutrition and generation."

In the whole range of science it would be difficult to select an utterance more prophetic of future knowledge than these few words. Huxley had been reading the investigations of von Baer into the early development of back-boned animals. He had learned from them the great generalisation, that the younger stages of these animals resemble one another more closely than the adult stages, and that in an early stage in the development of all these animals the beginning of the embryo consists of two layers of cells, in fact of two foundation-membranes, one forming specially the wall of the future digestive canal, the other forming the most external portion of the future animal. In those days nothing could have seemed a remoter

or more unlikely comparison than one instituted between Medusæ and the embryonic stages of backboned animals. But Huxley made it, not allowing the evidence brought before his reason to be swamped by preconceived ideas. At the time he did no more than to make the comparison. It was much later that the full importance of it became known, when more extended work on the embryology of vertebrates and of the different groups of the invertebrates had made it plain that the two foundation-membranes of Huxley occur in all animals from the Medusæ up to man. In the group of Cœlentera the organisation remains through all life as nothing more than a folding in and folding out of these membranes. The early stages of all the higher animals similarly consist of complications of the two membranes; but later on there is added to them a third membrane. Thus the group that Huxley gathered together comprises those animals that as adults remain in a condition of development which is passed through in the embryonic life of all higher animals. The immense importance of this conclusion becomes plain, and the conclusion itself seems obvious, when seen in the light of the doctrine of descent. The group of Cœlentera represents a surviving, older condition in the evolution of animals. Huxley himself, when on the *Rattlesnake*, regarded evolution only as an abstract conception, and he made the comparison which has been described without any afterthought of what it implied. In this we have the earliest authentic instance of the peculiar integrity of mind which was so characteristic of him in his dealings with philosophy and tradition. He never allowed any weight of authority or any apparent disturbance of existing ideas to alter the conclusions to which his reason led him. This intellectual courage made him the appropriate leader in the battle for evolution and against traditional thought, and we shall find again and again in consideration of his work that it was the keynote of his life.

CHAPTER IV

EARLY DAYS IN LONDON

THE *Rattlesnake* was paid off at Chatham on November 9, 1850. In the natural course of events Huxley would have been appointed before long to active service upon another ship. But he had no intention of relapsing into the position of a mere navy doctor; he had accumulated sufficient scientific material to keep him employed on scientific investigation for years, and so he applied to the Admiralty to "be borne on the books" of H.M.S. *Fisgard* at Woolwich—that is to say, to be appointed assistant-surgeon to the ship "for particular service," so that he should not be compelled to live on board, but might remain in town, and, with free access to libraries and museums, work up the observations he had made on the *Rattlesnake* into serious and substantial contributions to science. His request was granted, largely by the aid of his old chief, Sir W. Burnett, who continued to take the most useful interest in the young man he had originally nominated to the service. In a letter to him Huxley described the investigations which he desired to continue as being chiefly those on "the anatomy of certain Gasteropod and Pteropod Mollusca, of Firola and Atlantis, of Salpa and Pyrosoma, of two new Ascidians, namely, Appendicularia and Doliolum, of Sagitta and certain Annelids, of the auditory and circulatory organs of certain transparent Crustacea, and of the Medusæ and Polyps." His request was granted, and for the next three years Huxley lived in London with his brother, on the

exiguous income of an assistant-surgeon, and devoted himself to research. He attained almost at once to the first rank among English anatomists. The result of the paper on Medusæ in the *Transactions of the Royal Society* was that he was elected a Fellow of the Society on June 5, 1851, and a year later received a Royal Medal of the Society. He made many warm friendships both among the older and the younger generations of scientific men. In his obituary notice of Huxley, Sir Michael Foster wrote :

"By Edward Forbes, in whose nature there was much that was akin to his own, and with whom he had some acquaintance before his voyage, he was at once greeted as a comrade, and with Joseph Dalton Hooker, to whom he was drawn at the very first by their common experience as navy surgeons, he began an attachment which, strengthened by like biological aspirations, grew closer as their lives went on. In the first year after his return, in the autumn of 1851, he made the acquaintance of John Tyndall at the meeting of the British Association at Ipswich, and the three, Hooker, Huxley, and Tyndall, finding how much in common were all their scientific views and desires, formed then and there a triple scientific alliance."

Repeated efforts were made by these three, and by more influential friends, to induce the Admiralty to contribute to the expense of publishing Huxley's scientific results, as they had given a pledge to encourage officers who had done scientific work. These efforts lasted unavailingly for nearly three years, and then, as Huxley says : "The Admiralty, getting tired, I suppose, cut short the discussion by ordering me to join a ship, which thing I declined to do, and, as Rastignac, in the *Père Goriot*, says to Paris, I said to London, *à nous deux*." This light phrase conceals a courageous and momentous decision. He was absolutely without private resources, and having abandoned his professional work he had no salary of any kind. For a year or so he supported himself by writing reviews and popular scientific articles, striving all the time not only to gain his bread but to continue

his scientific work and make it known to the public. He desired to get a professorship of physiology or of comparative anatomy, and as vacancies occurred he applied, but unsuccessfully. At the same time, he tells us, he and his friend, John Tyndall, were

"candidates, he for the Chair of Physics, and I for that of Natural History in the University of Toronto, which, fortunately, as it turned out, would not look at either of us. I say fortunately, not from any lack of respect for the University of Toronto; but because I soon made up my mind that London was the place for me, and hence I have steadily declined the inducements to leave it which have at various times been offered."

In these early years in London Huxley's work was most varied. A large number of anonymous articles by him appeared in the *Literary Gazette*, and in other periodicals. He assisted to remove the insular narrowness from English scientific work by translating many foreign memoirs. With the collaboration of Mr. Henfrey, he edited a series of scientific memoirs, all of which were translated from foreign languages, and many by his own pen. With the assistance of Mr. George Busk he made a translation of Kölliker's *Histology*, a great treatise on microscopic anatomy which played a large part in the development of the modern English schools of anatomy and physiology. He made some valuable contributions to Todd and Bowman's *Cyclopædia of Anatomy*, an elaborate publication now nearly forgotten and superseded, but which was the standard anatomical work of the middle of the nineteenth century. He did not finish his work upon oceanic Medusæ, as he was uncertain how to have it published; the Admiralty refused to assist, and it was too lengthy for publication in the volumes of the learned Societies. As a matter of fact, he did not publish it until 1858, when it appeared as a separate memoir. To the *Quarterly Journal of Microscopical Science* and to the *Transactions* of the Royal and Linnæan Societies he contributed several memoirs dealing with the

microscopic anatomy and relationships of invertebrates, and, lastly, he gave a series of addresses at the Royal Institution, which had been founded as a means by which leading men of science might give accounts of their work to London society. Abstracts of these lectures are published in the early volumes of the *Proceedings of the Royal Institution* and are interesting as shewing the kinds of zoological subjects which were attracting the attention of Huxley and which he considered of sufficient interest and importance to bring to the notice of the general public. The first of these lectures, and probably the first given in public by Huxley, delivered on April 30, 1852, was entitled "Animal Individuality." The problem as to what is meant by an individual had been raised in his mind by consideration of many of the forms of marine life, notably compound structures like the Portuguese man-of-war, and creatures like the salps, which form floating chains many yards in length. He explained that the word *individual* covers at least three different kinds of conceptions. There is, first, what he described as arbitrary individuality, an individuality which is given by the mind of the observer and does not actually exist in the thing considered. Thus a landscape is in a sense an individual thing, but only so far as it is a particular part of the surface of the earth, isolated for the time in the mind of the person looking at it. If the observer shift his position, the range of the landscape alters and becomes something else. Next there are material, or practically accidental individual things, such as crystals or pieces of stone; and, lastly, there are living individuals which, as he pointed out, were cycles. All living things are born into the world, grow up, and die, and it was to the cycle of life from the egg to the adult which produces eggs, that he gave the name individual. In a simple animal like Hydra there is no difficulty in accepting this plain definition of individuality; but Huxley went on to compare with Hydra a compound creature like the Portuguese man-of-war, which

really is composed of a colony of Hydra-like creatures, the different members of the colony being more or less altered to serve different functions. All these have come from the branching of a single simple creature produced from an egg, and to the whole colony Huxley gave the name of zoological individual. The salps give a still wider interpretation to this view of individuality. The original salp produced from the egg gives rise to many salps, which may either remain attached in a chain, or, breaking away, may live separately. Huxley extended the use of the word individual so as to include as a single zoological individual the whole set of creatures cohering in chains or breaking apart, which had been produced by budding from the product of a single egg-cell. This subtle analysis of ideas delighted and interested his contemporaries, and the train of logical examination of what is meant by individuality has persisted to the present time. Like all other zoological ideas, this has been considerably altered by the conception of evolution. Zoologists no longer attempt to stretch logical conceptions until they fit enormous and different parts of the living world. They recognise that the living world, because it is alive, is constantly changing, and that living things pass through different stages or kinds of individuality in the course of their lives. A single egg-cell is one kind, perhaps the simplest kind, of zoological individual; when it has grown up into a simple polyp it has passed into a second grade of individuality; when, by budding, the polyp has become branched, a third grade is reached, and when the branches have become different, in obedience to the different purposes which they are to serve in the whole compound creature, a still further grade is reached. Huxley's attempt to find a meaning for individuality that would apply equally to a single simple creature, to a compound creature, and to the large number of separate creatures, all developed by budding from one creature, is a striking instance of his capacity for bringing apparently dissimilar facts into harmony, by finding

out the common underlying principle, and, although we no longer accept this particular conclusion, we cannot fail to notice in it the peculiar powers of his mind.

A second and even more interesting Royal Institution lecture dealt with the "Identity of Structure in Animals and Plants." At the present time every educated person knows that the life of animals and plants alike depends on the fact that their bodies are composed of a living material called protoplasm, a material which is identical in every important respect in both kingdoms of the living world. In the middle of the nineteenth century, scientific opinion was by no means clear on this matter, and certainly public opinion was most vague. Huxley discussed what was meant by organisation, and shewed that plants and animals alike were organised beings. Then he went on to explain the cellular theory of Schwann, which was then a novelty to a general audience. Schwann, in studying the microscopic structure of plants, noticed that their bodies were made up of little cases with firm walls; these he called *cells*, and declared that the whole body of the plant was composed of cells. As the walls of these cells were the most obvious and visible feature, it was supposed that they were the most essential part of the structure, and there was some difficulty in applying the cellular theory to the bodies of animals, as in most cases there are no easily visible cell-walls in animal tissues. As the result of his own observation, and from his reading of the work of others, Huxley laid down in the clearest way what is now accepted by everyone—that the presence of walls is of minor interest, and that the important element is the slimy contents of the cells, what is called "protoplasm." He declared that the protoplasm of animals was identical with the protoplasm of plants, and that plants were "animals confined in wooden cases." He agreed with Schwann that the cell, using the term to imply the contents rather than the wall, was of fundamental importance, and was the unit of

structure of the whole world of life. On the other hand, he declared that it could not be looked at as the unit of function : he denied that the powers and properties of a living body were simply the sum of the powers and properties of the single cells. In this opinion he was not followed by physiologists until quite recently. For many years physiologists held that cells were units of function just as much as they are units of structure; but more recently there has been a strong return to the opinion of Huxley.

In 1851 two important memoirs were published in the *Transactions of the Royal Society*, which contained the results of Huxley's observations of the interesting animals known as "tunicates." The first of these papers begins as follows :

"The Salpæ, those strange gelatinous animals, through masses of which the voyager in the great ocean sometimes sails day after day, have been the subject of a great controversy since the time of the publication of the celebrated work of Chamisso, *De Animalibus Quibusdam e Classe Vermium Linnæana*. In this work there were set forth, for the first time, the singular phenomena presented by the reproductive processes of these animals—phenomena so strange, and so utterly unlike anything then known to occur in the whole province of zoology, that Chamisso's admirably clear and truthful account was received with almost as much distrust as if he had announced the existence of a veritable Peter Schlemihl."

According to Chamisso, salps appeared in two forms : solitary forms, and forms in which a number of salps are united into a long chain. Each salp in a chain contains an embryo receiving nutrition from the mother by a connection similar to the placenta by which the embryo of a mammal receives nourishment from the blood of the mother. These embryos grow up into the solitary form, and the solitary form gives rise to a long chain of the aggregate form which develops in the interior of the body. Chamisso compared this progress with the development of insects. "Supposing," he said,

"caterpillars did not bodily change into butterflies, but by a process of a sexual breeding produced young which grew into the ordinary adults, and that these adults, as indeed they do, gave rise to caterpillars by sexual reproduction, then there would be a true alternation of generations." The first generation would give rise to a second generation totally unlike itself, and this second generation would reproduce, not its kind, but the first generation; such an alternation of generations he stated to occur among the salps. Huxley had an excellent opportunity of studying this question at Cape York in November, 1849. "For a time the sea was absolutely crowded with Salpæ, in all stages of growth, and of size very convenient for examination." He was able to verify the general truth of Chamisso's statement. The aggregate form of Salpa always gives rise to the solitary salps, and the solitary salps always gives rise to chains of the aggregate salps. But the process of reproduction he shewed to be quite different in the two cases. The solitary salp produces in its interior a little stolon or diverticulum which contains an outgrowth from the circulatory system, and this stolon gradually becomes pinched off into the members of the chain of the aggregate form. The salps of the aggregate form are therefore merely buds from the solitary form, and are not produced in the ordinary way, by sexual generation. On the other hand, each salp of the chain has within it a true egg-cell. This is fertilised by a male cell, and grows up into the solitary form, within the body of the parent, nourished by the blood of the parent. There is then an alternation of generations, but there are not two sexual generations. The sexual generation of chain salps gives rise to forms which reproduce by buds. From this conclusion, with which all later observers have agreed, Huxley went on to his theory of individuality. Different names had been given to the two forms, but Huxley declared that neither form was a true zoological individual; they were only parts of individuals or organs, and the

true individual was the complete cycle involving both forms.

In addition to determining the interesting method of reproduction, Huxley made an elaborate investigation of the structure of Salpa. On one occasion only the *Rattlesnake* came across a quantity of an allied Ascidian, Pyrosoma, which had received its name from its phosphorescence.

"The sky was clear but moonless, and the sea calm; and a more beautiful sight can hardly be imagined than that presented from the deck of the ship as she drifted, hour after hour, through this shoal of miniature pillars of fire gleaming out of the dark sea, with an ever waning, ever brightening, soft bluish light, as far as the eye could reach on every side. The Pyrosomata floated deep, and it was only with difficulty that some were procured for examination and placed in a bucketful of sea-water. The phosphorescence was intermittent, periods of darkness alternating with periods of brilliancy. The light commenced in one spot, apparently on the surface of one of the zooids, and gradually spread from this as a centre in all directions; then the whole was lighted up: it remained brilliant for a few seconds, and then gradually faded and died away, until the whole mass was dark again. Friction at any point induces the light at that point, and from thence the phosphorescence spreads over the whole, while the creature is quite freshly taken; afterwards, the illumination arising from friction is only local."

Dealing with these creatures in the broad anatomical spirit in which he had studied the Medusæ, Huxley shewed the typical structure manifested in the different forms, and that was common to them and the Ascidians or sea-squirts of the seashore. In a second paper on "Appendicularia and Doliolum" he made further contributions to our knowledge of these interesting creatures. Appendicularia is a curious little Ascidian, differing from others in its possession of a tail. Earlier observers had obtained it on various parts of the ocean surface, but had failed entirely to detect its relationship to the ordinary Ascidians. Chamisso got it near Behring's Straits and thought that it

was more nearly allied to "Venus's Girdle," a Cœlenterate. Mertens, another distinguished zoologist, had declared that "the relation of this animal with the Pteropods (a group of molluscs) is unmistakable"; while Müller, a prince among German anatomists, confessed that "he did not know in what division of the animal kingdom to place this creature." Huxley shewed that it possessed all the characteristic features of the Ascidians, the same arrangement of organs, the same kind of nervous system, a respiratory chamber formed from the fore part of the alimentary canal, and a peculiar organ running along the pharynx which Huxley called the endostyle and which is one of the most striking peculiarities of the whole group. The real nature of the tail was Huxley's most striking discovery. He pointed out that ordinary Ascidians begin life as tiny tadpole-like creatures which swim freely by the aid of a long caudal appendage; and that while these better-known Ascidians lose their tails when they settle down into adult life, the Appendiculariæ are Ascidians which retain this larval structure throughout life. Von Baer had shown that in the great natural groups of higher animals some forms occur which typify, in their adult condition, the larval state of the higher forms of the group. Thus, among the amphibia, frogs have tails in the larval or tadpole condition; but newts throughout life remain in the larval or tailed condition. Appendicularia he considered to be the lowest form of the Ascidians, and to typify in its adult condition the larval stages of the higher Ascidians.

By this remarkable investigation of the structure of the group of Ascidians, and display of the various grades of organisation, Huxley paved the way for one of the great modern advances in knowledge. When, later on, the idea of evolution was accepted, and zoologists began hunting out the pedigree of the back-boned animals, it was discovered that Ascidians were modern representatives of an important stage in the ancestry of vertebrate animals, and, therefore, of man himself.

There are few more interesting chapters in genealogical zoology than those which reveal the relationship between Amphioxus and fish on the one hand, and Ascidians on the other; for fish are vertebrates, and Ascidians, on the old view, are lowly invertebrates. The details of these relationships have been made known to us by the brilliant investigations of several Germans, by Kowalevsky, a Russian, by the Englishmen Ray Lankester and Willey, and by several Americans and Frenchmen. But behind the work of all these lies the pioneer work of Huxley, who first gathered the group of Ascidians together, and in a series of masterly investigations described its typical structure.

Huxley's next great piece of work was embodied in a memoir published in the *Transactions of the Royal Society* in 1853, and which remains to the present day a model of luminous description and far-reaching ideas. It was a treatise on the structure of the great group of molluscs, and displays in a striking fashion his method of handling anatomical facts, and deducing from them the great underlying principles of construction. The shell-fish with which he dealt specially were those distinguished as cephalous, because, unlike creatures such as the oyster and mussel, they had something readily comparable with the head of vertebrates. He began by pointing out what problems he hoped to solve. The anatomy of many of the cephalous molluscs was known, but the relation of structures present in one to structures present in another group had not been settled.

"It is not settled whether the back of a cuttle-fish answers to the dorsal or ventral surface of a gasteropod. It is not decided whether the arms and funnels of the one have or have not their homologues in the other. The dorsal integument of a Doris and the cloak of a whelk are both called 'mantle,' without any evidence to shew that they are really homologous. Nor do very much more definite notions seem to have prevailed with regard to the archetypal molluscous form, and the mode in which (if such an archetype exist) it becomes modified in the different secondary types."

He had taken from the surface of the sea a number of transparent shell-fish, and had been able to study the structures and arrangement of their organs "by simple inspection, without so much as disturbing a single beat of their hearts." From knowledge gained in this fashion, and from ordinary dissection of a number of common snails, cephalopods, and pteropods, he was able to describe in a very complete way the anatomical structure of cephalous molluscs. The next natural step, he stated, would have been to describe the embryonic development of the organs of these different creatures in order that a true knowledge might be gained of what were the homologous or really corresponding parts in each. Having had no opportunity to make such embryological studies for himself, he fell back on numerous accounts of development by Kölliker, van Beneden, Gegenbaur, and others, and so gradually arrived at a conception of what he called the "archetype" of the cephalous molluscs. As the word *archetype* was borrowed from old metaphysical ideas dating back to the time of Plato, he took care to state that what he meant by it was no more than a form embodying all that could be affirmed equally respecting every single kind of cephalous mollusc, and by no means an "idea" upon which it could be supposed that animal forms had been modelled. He described this archetype, and showed the condition of the different systems of organs which it could be supposed to possess, and how these organs were modified in the different existing groups. Huxley's archetypal mollusc was a creature with a bilaterally symmetrical head and body. On the ventral side of the body it possessed a peculiar locomotor appendage, the so-called foot, and the dorsal surface of the body secreted a shell. Its nervous system consisted of three pairs of ganglia or brains, one pair in the head, one in the foot, and a third in the viscera. He shewed that the widely different groups of cephalous molluscs could be regarded as modifications of this structure, and extended the conception so as to cover all other molluscs.

Apart from the anatomical value of this paper, and although all technical details have been omitted here, it is necessary to say that merely as a series of intricate anatomical descriptions and comparisons, this memoir was the most valuable of any that Huxley wrote. The working out of the theory of the archetype is peculiarly interesting to compare with modern conceptions. To those of us who began biological work after the idea of evolution had been impressed upon anatomical work, it is very difficult to follow Huxley's papers without reading into them evolutionary ideas. In the article upon Mollusca, written for the ninth edition of the *Encyclopædia Britannica*, by Professor Ray Lankester, the same device of an archetypal, or, as Lankester calls it, a schematic mollusc, is employed in order to explain the relations of the different structures found in different groups of molluscs to one another. Lankester's schematic mollusc differs from Huxley's archetypal mollusc only as a finished modern piece of mechanism, the final result of years of experiment, differs from the original invention. The method of comparing the schematic mollusc with the different divergent forms in different groups is identical, and yet, while the ideas of Darwin are accepted in every line of Lankester's work, Huxley was writing six years before the publication of *The Origin of Species*. There was growing up in Huxley's mind, partly from his own attempts to arrange anatomical facts in an intelligible series, the idea that the divergencies of structure to be found within a group had come about by the modification of an original type. Not only did he conceive of such an evolution as the only possible explanation of the facts, but he actually used the word *evolution* to convey his ideas. On the other hand, he was firmly convinced that such evolution was confined within the great groups. For each group there was a typical structure, and modifications by defect or excess of the parts of the definite archetype gave rise to the different members of the group. Moreover, he confined this evolution in the

strictest possible way to each group; he did not believe that what was called anamorphosis—the transition of a lower type into a higher type—ever occurred. To use his own words:

"If, however, all Cephalous Mollusca, *i.e.*, all Cephalopoda, Gasteropoda, and Lamellibranchiata, be only modifications by excess or defect of the parts of a definite archetype, then, I think, it follows as a necessary consequence, that no anamorphosis takes place in this group. There is no progression from a lower to a higher type, but merely a more or less complete evolution of one type. It may indeed be a matter of very grave consideration whether true anamorphosis ever occurs in the whole animal kingdom. If it does, then the doctrine that every natural group is organised after a definite archetype, a doctrine which seems to me as important for zoology as the theory of definite proportions for chemistry, must be given up."

It is of great historical interest to notice how actual consideration of the facts of the animal kingdom led zoologists close to an idea of evolution, and yet how far they were from it as we hold it now. It is fashionable at the present time to attempt to depreciate the immense change introduced by Darwin into zoological speculation, and the method employed is largely partial quotation, or reference to the kind of ideas found in papers such as this memoir by Huxley. The comparison between the types of the great groups and the combining proportions of the chemical elements shows clearly that Huxley regarded the structural plans of the great groups as properties necessary and inherent in these groups, just as the property of chemical element to combine with another chemical substance only in a fixed proportion is necessary and inherent in the existing conception of it. There was no glimmer of the idea that these types were not inherent, but merely historical results of a long and slow series of changes produced by the interaction of the varied conditions of life and the intrinsic qualities of living material.

In two lectures delivered at the Royal Institution in 1854 and 1855, the one on "The Common Plan

of Animal Forms," the other on "The Zoological Arguments Adduced in Favour of the Progressive Development of Animal Life in Time," shew, so far as the published abstracts go, the same condition of mind. The idea of progressive development of all life from common forms was not unknown to Huxley and his contemporaries, but was rejected by them. In the first of these two lectures he took four great groups of animals, the Vertebrata, the Articulata, the Mollusca, and the Radiata, and explained what was the archetype of each. He shewed the distinctiveness of each plan of structure, and then discussed the relations of the ideas suggested by von Baer to these archetypes. He stated explicitly that while the adult forms were quite unlike one another, there were traces of a common plan to be derived from a study of their embryonic development. Such a trace of a common plan he had himself suggested when he compared the foundation-membranes of the Medusæ with the first foundation-membranes of vertebrate embryos. This was going a long way towards modern ideas; but he stopped short, and gave no hint that he believed in the possibility of the development of one plan from a lower or simpler plan. The second lecture dealt with the kind of ideas which were crystallised in the popular but striking work of Chambers, entitled *Vestiges of Creation*. Chambers attacked the theological view that all animals and plants had been created at the beginning of the world, and maintained that geological evidence shewed the occurrence of a progressive development of animal life. Huxley, like all zoologists and geologists who knew anything of the occurrence of fossils in the rocks of past ages, agreed with the general truth of the conception that a progressive development had occurred which shewed that the species now existing were represented in the oldest rocks by species now extinct. But the examples he brought forward were all limited to evolution within the great groups, and did not affect his idea that archetypes were fixed and did not pass into each other. More-

over, he summed up strongly against the suggestion that there was any parallel between the succession of life in the past and the forms assumed by modern animals in their embryological development. So far as the present writer is able to judge from study of the literature of this period, the possibility of evolution was present in an active form in the mind of Huxley and of his contemporaries, and in an extraordinary way they brought together evidence which afterwards became important; but the idea in its modern sense was rejected by them.

In 1854 Huxley's uncomfortable period of probation came to an end. Edward Forbes, who held the posts of Palæontologist to the Geological Survey, and Lecturer on General Natural History at the Metropolitan School of Science Applied to Mining and the Arts, vacated these on his appointment to the Chair of Natural History in the University of Edinburgh, and Sir H. De La Beche, the then Director-General of the Geological Survey, offered both the posts to Huxley—who in June and July of that year had given lectures at the school in place of Forbes. Huxley says himself:

"I refused the former point-blank, and accepted the latter only provisionally, telling Sir Henry that I did not care for fossils, and that I should give up natural history as soon as I could get a physiological post. But I held the office for thirty-one years, and a large part of my work has been palæontological."

The salary of the post of Lecturer on Natural History was small, but De La Beche, who recognised Huxley's genius, and was anxious to have him attached even against his will to palæontological work, created the new post of Naturalist to the Geological Survey, by which a more suitable income was found for him. His official duties were at first in the Geological Museum of the Survey, but were distinguished from those of the special Palæontologist, Mr. Harvey. His income was now assured, and for the rest of his life, until towards its close, when he retired to Eastbourne,

he lived the ordinary life of a professional man of science in London.

The ambitious but raw youth, armed with a restless spirit of inquiry, and a determined power of work, but without powerful friends or weighty influence, had graduated with honours in the University of the world, and for the rest of his life was in secure possession of high scientific and social position. It is not difficult to understand how he gained his scientific position; he had ambition, power of work, opportunity, and the high form of mental ability that it is convenient to class as genius. As soon as he succeeded in gaining a hearing, he was welcomed to the inner circle of science, for although personal rivalries play a part in the affairs of science as in other human avocations, it is the fundamental training of men of science to be interested in discoveries objectively; there is so much to know, and so few who really advance knowledge, that a genuine new-comer has an easier entrance than in most walks of life. Forbes and Hooker, Darwin, Tyndall and Herbert Spencer became friends of Huxley almost at once, and remained his intimate friends permanently. Owen was at first friendly; it was only later, when his position as the English Cuvier was sapped, and in the stress of the Darwinian controversy, that his sweet politeness to Huxley recalled Mrs. Carlyle's description of it as the " sweetness of sugar-of-lead."

Huxley's great social success requires rather more explanation. A young surgeon of unknown family did not necessarily find that brilliant investigations on the anatomical position of Medusæ or on the individuality of Salpa were a secure passport to a society which was even more than now steeped in the traditions of the universities, and the greater public schools. From the beginning, however, Huxley had been laying for himself the foundations of general culture. As a boy he had read Hume, Mackintosh and Guizot, and was a deep student and admirer of Carlyle. An extract from his diary written when he was twenty is in the

manner and almost the words of Carlyle. Although in later years the doctrine of the descent of man made Darwin and Huxley intolerable to Carlyle, Huxley never forgot his debt. His son relates that near the end of Carlyle's life, Huxley saw him walking slowly and alone down the opposite side of the street, and touched by his solitary appearance, crossed over and spoke to him. The old man looked, and merely remarking, "You're Huxley, aren't you? the man that says we are all descended from monkeys," went on his way.

The rough-and-tumble life of a London medical student gave him the beginning of knowledge of men, the surest foundation of knowledge of manners. Huxley himself, however, thought that his four years' close confinement with a little group of officers and men in the strict discipline of the navy was more than the equivalent of life at a public school or university.

Much of the work of the *Rattlesnake* was in Australian waters, and Huxley was able to stay in Sydney for a considerable time on several occasions. His commission in the navy gave him a good introduction, and it was in Sydney that he had his first opportunity of entering the social world on equal terms. It was at Sydney that he met his future wife, Miss Henrietta Anne Heathorn. In a letter to his brother written in 1848 ("Life and Letters," p. 37), he gives the following account of this:—"What do you think of your grave, scientific brother turning out a ball-goer and doing the light fantastic to a great extent? It is a fact, I assure you. But there is a method in my madness. I found it exceedingly disagreeable to come to a great place like Sydney and think there was not a soul who cared whether I was alive or dead, so I determined to go into what society was to be had and see if I could not pick up a friend or two among the multitude of the empty and frivolous. I am happy to say that I have had more success than I hoped for or deserved, and there are now two or three houses where I can go and feel myself at home at all

times. But my "home" in Sydney is the house of my good friend Mr. Fanning, one of the first merchants in the place. But thereby hangs a tale which, of all people in the world, I must tell you. Mrs Fanning has a sister, and the dear little sister and I managed to fall in love with one another in the most absurd manner, after seeing one another —I will not tell you how few times, lest you should laugh. Do you remember how you used to talk to me about choosing a wife? Well, I think my choice would justify even your fastidiousness. . . . I think you will understand how happy her love ought to and does make me."

In a letter to his mother, written a year later, he says:—"I must thank you for your very kind letter of September, 1848. I read the greater part of it to Nettie, who was as much pleased as I with your kindly wishes towards both of us. Now I suppose I must do my best to answer your questions. First, as to age, Nettie is about three months younger than myself—that is the difference in *our years*, but she is *in fact* as much younger than her years as I am older than mine. Next, as to complexion, she is exceedingly fair, with the Saxon yellow hair and blue eyes. Then as to face, I really don't know if she is pretty or not. I have never been able to decide the matter in my own mind. Sometimes I think she is, and sometimes I wonder how the idea ever came into my head. Whether or not, her personal appearance has nothing whatever to do with the hold she has on my mind, for I have seen hundreds of prettier women. But I never met with so sweet a temper, so self-sacrificing and affectionate a disposition, or so pure and womanly a mind, and from the perfectly intimate footing on which I stand with her family, I have plenty of opportunities of judging. As I tell her, the only great folly I am aware of her being guilty of, was the leaving her happiness in the hands of a man like myself, struggling upwards and certain of nothing."

The lovers had to wait for a long time, whilst the "struggle upwards" was in progress, and did not

see each other for years. When in 1855 Huxley was in a position to marry, and Miss Heathorn and her parents arrived in England, the young lady's health had broken down utterly. His son relates ("Life and Letters," I. p. 127), that Huxley took her to a famous London doctor, and, as one member of the profession to another, asked him privately his opinion of the case. "I give her six months of life," said Æsculapius. "Well, six months or not," replied Huxley, "she is going to be my wife." The doctor was mightily put out, but Huxley avoided the evasive opinion he would otherwise have received.

The marriage took place on July 21, 1855, and was followed by a long life of complete sympathy and happiness. Even Darwin's warning, "I hope your marriage will not make you idle; happiness, I fear, is not good for work," was unnecessary, because in all his strenuous subsequent career, Huxley was assisted and encouraged by his wife in every way, and much of his controversial writing was submitted to her critical judgment in manuscript.

During the years 1856, 1857, and 1858, he held the post of Fullerian Professor of Physiology in the Royal Institution, choosing as the title of his first two courses of lectures Physiology and Comparative Anatomy, as he still cherished the idea of being in the first place a physiologist.

"Moreover," writes Professor Michael Foster, "like most other young professional men of science, he had to eke out his not too ample income by labours undertaken chiefly for their pecuniary reward. He acted as examiner, conducting for instance, during the years 1856 to 1863, and again 1865 to 1870, the examinations in physiology and comparative anatomy at the University of London, making even an examination paper feel the influence of the new spirit in biology; and among his examinees at that time there was at least one who, knowing Huxley's writings, but his writings only, looked forward to the *viva voce* test, not as a trial but as an occasion of delight. He wrote almost incessantly for all editors who were prepared to give adequate pay to a pen able to deal with scientific themes

in a manner at once exact and popular, incisive and correct."

In 1858 he was invited to give the Croonian Lecture at the Royal Society, and deliberately chose as his subject the theory of the vertebrate skull. Apart from its direct scientific value, this lecture was of importance as marking the place to which Huxley had attained in the scientific world. Two years later, it is true, the London *Times*, referring to a famous debate at a meeting of the British Association at Oxford, spoke of him as "a Mr. Huxley"; but in the scientific world he was accepted as the leader of the younger anatomists, and as one at least capable of rivalling Owen, who was then at he height of his fame. The Croonian Lecture was in a sense a deliberate challenge to Owen, and in these days before Darwin, to challenge Owen was to claim equality with the greatest living name in anatomical science.

CHAPTER V

CREATURES OF THE PAST

ALTHOUGH Huxley took a post connected with geology only because it was the most convenient opening for him, it was not long before he became deeply interested not only in the fossils, which at first he despised, but in the general problems of geology. He began by co-operation with Mr. Salter in the determination of fossils for the Geological Survey. The mere work of defining genera and species and naming and describing new species appealed very little to him. He had none of the collector's passion for new species; his interest in a creature being not whether or no it was new to science, but what general problems of biology its structure helped to elucidate. While he assisted in the routine work of determining the zoological position of the fossils sent in to the museum by the Survey, he carried investigations much farther than the duties of the post required when interesting zoological problems arose. His earliest notes were written in association with his colleague, and consisted of technical descriptions of some small fossils from the Downton Sandstones which were supposed to be fish-shields. The peculiarities of structure presented by these aroused his interest, and he began an elaborate series of investigations upon palæozoic fishes in general. Earlier zoologists, such as the great Agassiz, had devoted most of their attention to careful and exact description of the different fossil fishes with which they became acquainted. Huxley at once began to investigate the relations that

existed among the different kinds of structure exhibited in the different fish. He laid down the lines upon which future work has been conducted, and, precisely as in the case of molluscs, he started future investigators upon lines of research the ends of which have not yet been reached. His work upon *Devonian Fishes*, published in 1861, threw an entirely new light upon the affinities of these creatures.

He made a similar, although less important, series of investigations upon some of the great extinct Crustacea; but, perhaps, his most important palæontological work was done later, after he had been convinced by Darwin of the fact of evolution. In 1855 he had expressed the opinion that the study of fossils was hopeless if one sought in it confirmation of the doctrine of evolution; but five-and-twenty years' continuous work completely reversed his opinion, and in 1881, addressing the British Association at York, he declared that "if zoologists and embryologists had not put forward the theory, it would have been necessary for palæontologists to invent it." In three special groups of animals his study of fossils enabled him to assist in bridging over the gaps between surviving groups of creatures by study of creatures long extinct. He began to study the structure of the Labyrinthodonts, a group of extinct monsters which received their name from the peculiar structure of their teeth. He published elaborate descriptions of Anthracosaurus from the coal-measures of Northumberland, of Loxomma from the lower carboniferous of Scotland, and of several small forms from the coal-measures of Kilkenny, in Ireland, as well as describing skulls from Africa and a number of fragmentary bones from different localities. But in all this work it was the morphology of the creatures that interested him, and the light which their structure threw upon the structure of each other and of their nearest allies. He shewed that these monsters stood on the borderland between fishes, amphibia, and reptiles, and he added much to our knowledge of

the true structure of these great groups. Next, he turned to the extinct reptiles of the Mesozoic age. It was generally believed that the Pterodactyls, or flying reptiles, were the nearest allies of birds, but Huxley insisted that the similarity of the wings was simply such superficial resemblance as necessarily exists in organs adapted to the same purpose. About the same time, Cope in America, and Phillips and Huxley, in England, from study of the bones of the Dinosaurs, another great group of extinct reptiles, declared that these were the nearest in structure to birds. In association with the upright posture, the ilium or great haunch-bone of birds extends far forwards in front of the articulation of the thigh-bone, so that the pelvis in this region has a T-shape, the ilium forming the cross-bar of the T, and the femur or thigh-bone the downward limb. Huxley shewed that a large number of the Dinosaurs had this and other peculiarities of the bird's pelvis, and separated these into a group which he called the "Ornithoscelida," seeing in them the closest representatives of the probable reptilian ancestors of birds. While further work and the discovery of a still greater number of extinct reptiles has made it less probable that these were the actual ancestors of birds, Huxley's work in this, as in the many other cases we have shewn, proved not only of great value in itself, but led to a continually increasing series of investigations by others. It is not always the pioneer that makes the greatest discoveries in a new country, but the work of the pioneer makes possible and easier the more assured discoveries of his followers.

A third great piece of palæontological investigation with which the name of Huxley will always be associated, is the most familiar of all the instances taken from fossils in support of the evolution of animals. This famous case is the pedigree of the horse. In 1870, in an address delivered to the Geological Society of London, Huxley had shewn that there was a series of animals leading backwards from the modern horse to a more

generalised creature called Anchitherium, and found in the rocks of the Miocene period. He suggested that there were, no doubt, similar fossils leading still further backwards towards the common mammalian type of animal, with five fingers and five toes, and went the length of suggesting one or two fossils which might stand in the direct line of ancestry. But in 1876 he visited America, and had the opportunity of consulting the marvellous series of fossils which Professor Marsh had collected from American Tertiary beds. Professor Marsh allowed him the freest use of his materials and of his conclusions, and the credit of the final result is to be shared at least equally between Marsh and Huxley. The final result was a demonstrative proof of a possible course of evolution of the horse, given in a lecture delivered by Huxley in New York on Sept. 22, 1876, and illustrated by drawings from specimens in Marsh's collection. The matter of the lecture has become so familiar a part of descriptive writing on evolution, and the treatment is so characteristic of Huxley's brilliant exposition, that it is worth while to make some rather long quotations from it. The lecture was published in the New York papers, and afterwards with other matter formed a volume of *American Addresses*, published by Macmillan, in London.

In most quadrupeds, as in ourselves, the forearm contains distinct bones called the radius and the ulna. The corresponding region in the horse seems at first to possess but one bone. Careful observation, however, enables us to distinguish in this bone a part which clearly answers to the upper end of the ulna. This is closely united with the chief mass of the bone which represents the radius, and runs out into a slender shaft which may be traced for some distance downwards on the back of the radius, and then in most cases thins out and vanishes. It takes still more trouble to make sure of what is nevertheless the fact, that a small part of the lower end of the bone of the horse's forearm, which is only distinct in a very young foal, is really the lower extremity of the ulna.

"What is commonly called the knee of a horse is its wrist. The 'cannon bone' answers to the middle one of the five metacarpal bones which support the

palm of the hand in ourselves. The 'pastern,' 'coronary,' and 'coffin' bones of veterinarians answer to the joints of our middle finger, while the hoof is simply a greatly enlarged and thickened nail. But, if what lies below the horse's 'knee' thus corresponds to the middle finger in ourselves, what has become of the four other fingers or digits? We find in the places of the second and fourth digits only two slender splint-like bones about two-thirds as long as the cannon bone, which gradually taper to their lower ends and bear no finger joints, or, as they are termed, phalanges. Sometimes small bony or gristly nodules are to be found at the bases of these two metacarpal splints, and it is probable that these represent rudiments of the first and fifth digits. Thus the part of the horse's skeleton which corresponds with that of the human hand contains one overgrown middle digit, and at least two imperfect lateral digits; and these answer, respectively, to the third, the second, and the fourth digits in man.

"Corresponding modifications are found in the hind limb. In ourselves, and in most quadrupeds, the leg contains two distinct bones, a large bone, the tibia, and a smaller and more slender bone, the fibula. But, in the horse, the fibula seems, at first, to be reduced to its upper end; a short slender bone united with the tibia and ending in a point below occupying its place. Examination of the lower end of a young foal's shin-bone, however, shows a distinct portion of osseous matter, which is the lower end of the fibula; so that the apparently single lower end of the shin-bone is really made up of the coalesced ends of the tibia and fibula, just as the apparently single lower end of the forearm bone is composed of the coalesced radius and ulna.

"The heel of the horse is the part commonly known as the hock; the hinder cannon bone answers to the middle metatarsal bone of the human foot, the pastern, coronary, and coffin bones, to the middle-toe bone; the hind hoof to the nail, as in the fore foot. And, as in the fore foot, there are merely two splints to represent the second and fourth toes. Sometimes a rudiment of a fifth toe appears to be traceable."

Having in the same fashion described the highly complicated and peculiar structure of the teeth of modern horses, Huxley proceeded:

"To anyone who is acquainted with the morphology of vertebrated animals, these characteristic structures of the horse show that it deviates widely from the

general structure of mammals; and that the horse type is, in many respects, an extreme modification of the general mammalian plan. The least modified mammals, in fact, have the radius and ulna, the tibia and fibula, distinct and separate. They have five distinct and complete digits on each foot, and no one of these digits is very much larger than the rest. Moreover, in the least modified mammals, the total number of the teeth is very generally forty-four, while in the horse the usual number is forty, and, in the absence of the canines, it may be reduced to thirty-six; the incisor teeth are devoid of the fold seen in those of the horse; the grinders regularly diminish in size from the middle of the series to its front end; while their crowns are short, early attain their full length, and exhibit simple ridges or tubercles, in place of the complex foldings of the horse's grinders.

"Hence the general principles of the hypothesis of evolution lead to the conclusion that the horse must have been derived from some quadruped which possessed five complete digits on each foot; which had the bones of the forearm and of the leg complete and separate; and which possessed forty-four teeth, among which the crown of the incisors and grinders had a simple structure; while the latter gradually increased in size from before backwards, at any rate in the anterior part of the series, and had short crowns.

"And if the horse had been thus evolved, and the remains of the different stages of its evolution have been preserved, they ought to present us with a series of forms in which the number of the digits becomes reduced; the bones of the forearm and leg gradually take on the equine condition; and the form and arrangement of the teeth successively approximate to those which obtain in existing horses.

"Let us turn to the facts and see how far they fulfil these requirements of the doctrine of evolution.

"In Europe abundant remains of horses are found in the Quaternary and later Tertiary strata as far as the Pliocene formation. But these horses, which are so common in the cave-deposits and in the gravel of Europe, are in all essential respects like existing horses, and that is true of all the horses of the later part of the Pliocene epoch. But, in the deposits which belong to the earlier Pliocene, and later Miocene epochs, and which occur in Britain, in France, in Germany, in Greece, in India, we find animals which are extremely like horses—which in fact are so similar to horses that you may follow descriptions given in works upon the anatomy of the horse, upon the skeletons of these animals—but which differ in some

important particulars. For example, the structure of their fore and hind limbs is somewhat different. The bones, which, in the horse are represented by two long splints, imperfect below, are as long as the middle metacarpal and metatarsal bones; and, attached to the extremity of each, is a digit with three joints of the same general character of those of the middle digit, only very much smaller. These small digits are so disposed that they could have had but very little functional importance, and they must have been rather of the nature of the dew-claws, such as are to be found in many ruminant animals. The *Hipparion*, as the extinct European three-toed horse is called, in fact presents a foot similar to that of the American *Protohippus* except that in *Hipparion* the smaller digits are situated further back, and are of smaller proportional size than in the *Protohippus*.

"The ulna is slightly more distinct than in the horse; and the whole length of it, as a very slender shaft, intimately united with the radius, is completely traceable. The fibula appears to be in the same condition as in the horse. The teeth of the *Hipparion* are essentially similar to those of the horse, but the pattern of the grinders is in some respects a little more complex, and there is a depression on the face of the skull in front of the orbit, which is not seen in existing horses.

"In the earlier Miocene and perhaps in the Eocene deposits of some parts of Europe, another distinct animal has been discovered, which Cuvier, who first described some fragments of it, considered to be a *Palæotherium*, but as further discoveries threw new light on its structure, it was recognised as a distinct genus, under the name of *Anchitherium*.

"In its general characters the skeleton of *Anchitherium* is very similar to that of the horse, in fact Lartet and de Blainville called it *Palæotherium equinum* or *Hippoides*; and De Cristol, in 1847, said that it differed from *Hipparion* in little more than the characters of the teeth, and gave it the name of *Hipparitherium*. Each foot possesses three complete toes: while the lateral toes are much larger in proportion to the middle toe than in *Hipparion*, and doubtless rested on the ground in ordinary locomotion. The ulna is complete and quite distinct from the radius, although firmly united with the latter. The fibula seems also to have been complete; its lower end, though intimately united with that of the tibia, is clearly united with that of the latter bone. There are forty-four teeth; the incisors have no strong pit. The

canines seem to have been well developed in both sexes. The first of the seven grinders, which, as I have said, is frequently absent, and, when it does exist, is small in the horse, is a good-sized and permanent tooth, while the grinder which follows it is but little larger than the hinder ones. The crowns of the grinders are short, and, although the fundamental pattern of the horse-tooth is discernible, the front and back ridges are less curved, the accessory pillars are wanting, and the valleys, much shallower, are not filled up with cement."

Then, after describing his early efforts to trace the descent of the horse from European fossils, Huxley goes on to relate the new light thrown on the matter from the American discoveries of Professor Marsh :

"You are all aware that, when your country was first discovered by Europeans, there were no traces of the existence of the horse in any part of the American continent. The accounts of the conquest of Mexico dwell on the astonishment of the natives of that country when they first became acquainted with that astounding phenomenon, a man seated upon a horse. Nevertheless, the investigations of American geologists have proved that the remains of horses occur in the most superficial deposits of both North and South America just as they do in Europe. Therefore, for some reason or other—no feasible suggestion on that subject, so far as I know, has been made—the horse must have died out on this continent at some period preceding the discovery of America. Of late years there has been discovered in your Western territories that marvellous accumulation of deposits, admirably adapted for the preservation of organic remains, to which I referred the other evening, and which furnishes us with a consecutive series of records of the fauna of the older half of the Tertiary epoch, for which we have no parallel in Europe. The researches of Leidy and others have shewn that forms allied to the *Hipparion* and the *Anchitherium* are to be found among these remains. But it is only recently that the admirably conceived and most thoroughly and patiently worked-out investigations of Professor Marsh have given us a just idea of the vast fossil wealth and of the scientific importance of these deposits. I have had the advantage of glancing over the collections in Yale Museum; and I can truly say that, so far as my knowledge extends, there is no collection from any one region and series of strata

comparable, for extent, or for care with which the remains have been got together, or for their scientific importance, to the series of fossils which he has deposited there. This vast collection has yielded evidence bearing on the question of the pedigree of the horse of the most striking character. It tends to show that we must look to America rather than to Europe for the original seat of the equine series; and that the archaic forms and successive modifications of the horse's ancestry are far better preserved here than in Europe.

"Professor Marsh's kindness has enabled me to put before you a diagram, every figure of which is an actual representation of some specimen which is to be seen at Yale at this present time.

"The succession of forms which he has brought together carries us from the top to the bottom of the Tertiaries. Firstly, there is the true horse. Next we have the American Pliocene form of the horse (*Pliohippus*): in the conformation of its limbs it presents some very slight deviations from the ordinary horse, and the crowns of the grinding teeth are shorter. Then comes the *Protohippus*, which represents the European *Hipparion*, having one large digit and two small ones on each foot, and the general characters of the forearm and leg to which I have referred. But it is more valuable than the European *Hipparion* for the reason that it is devoid of some of the peculiarities of that form—peculiarities which tend to show that the European *Hipparion* is rather a member of a collateral branch than a form in the direct line of succession. Next, in the backward order in time, is the *Miohippus*, which corresponds pretty nearly with the *Anchitherium* of Europe. It presents three complete toes—one large median and two smaller lateral ones: and there is a rudiment of that digit which answers to the little finger of the human race.

"The European pedigree of the horse stops here; in the America Tertiaries, on the contrary, the series of ancestral equine forms is continued into the Eocene formations. An older Miocene form, called *Mesohippus*, has three toes in front, with a large splint-like rudiment representing the little finger; and three toes behind. The radius and ulna, the tibia and fibula, are distinct, and the short-crowned molar teeth are *Anchitherioid* in pattern.

"But the most important discovery of all is the *Orohippus* which comes from the Eocene formation, and is the oldest member of the equine series yet known. Here we find four complete toes on the front limb, three toes on the hind limb, a well-developed

ulna, a well-developed fibula, and short-crowned grinders of a simple pattern.

"Thus, thanks to these important researches, it has become evident that, so far as our present knowledge extends, the history of the horse type is exactly and precisely that which could have been predicted from a knowledge of the principles of evolution; and the knowledge we now possess justifies us completely in the anticipation that, when the still lower Eocene deposits, and those which belong to the Cretaceous period have yielded up their remains of ancestral equine animals, we shall find, first, a form with four complete toes and a rudiment of the innermost or first digit in front, with probably a rudiment of the fifth digit in the hind foot; while, in the older forms, the series of digits will be more and more complete until we come to the five-toed animals, in which, if the doctrine of evolution is well founded, the whole series must have taken its origin."

Just as Huxley was successful, when only the ancestry to Miocene times was known, in predicting the discovery of older forms in the older Miocene and upper Eocene, so his prediction of older Eocene forms carrying the chain back to five-toed creatures proved correct. One of the new links was indeed discovered before his lecture had passed through the press, and he was able to add in a footnote some details of the structure of the four-toed Eohippus from the lower Eocene beds. Further discoveries have connected these with the five-toed ancestors of the Tapirs, and there is the strongest reason to suppose that we now know as nearly as possible the line of ancestry of the horse back to the primitive forms common to all the higher mammals. It would, of course, be beyond possibility of proof that the exact fossils described were the actual ancestors of the horse; but that they are exceedingly close allies of these, and that among them some actual ancestors exist cannot reasonably be doubted.

Although he had embarked upon geological work with some distaste, Huxley became closely associated with it as years went on, and indeed, about the seventies, had abandoned his intention to devote himself specially to physiology, and

declared himself to be in the first place a palæontologist. In 1876 he had accomplished so much that the Geological Society gave him its chief distinction, awarding him the Wollaston Medal in recognition of his services to geological science. He acted as Secretary to the Geological Society from 1859 to 1862, and he was President from 1868 to 1870. In 1862, the President being incapacitated, Huxley as Deputy-President, delivered the Presidential Address. This address is famous in the history of geology, because for the first time it stated clearly and in permanent form a doctrine now taken as a first principle in all geological text-books. A large part of geology is the attempt to read the past history of the earth from the evidence given by the successive strata of rocks that form its crust.

"It is mathematically certain that, in any given vertical linear section of an undisturbed series of sedimentary deposits, the bed which lies lowest is the oldest. In many other vertical linear sections of the same series, of course corresponding beds will occur in a similar order."

It is of the utmost importance to determine whether or no the same series occurring vertically in the same order in different parts of the earth were deposited at the same time. To explain the problem, Huxley took the following concrete example:

"The Lias of England and the Lias of Germany, the Cretaceous rocks of Britain and the Cretaceous rocks of Southern India, are termed by geologists 'Contemporaneous' formations; but whenever any thoughtful geologist is asked whether he means to say that they were deposited at the same time, he says, 'No, only within the same great epoch.' And if, in pursuing the enquiry, he is asked what may be the approximate value in time of a 'great epoch'—whether it means a hundred years, or a thousand, or a million, or ten million years—his reply is, 'I cannot tell.'"

Most of the standard writers on palæontology had assumed that the presence in two beds at different parts of the world of the same fossils implied that the beds were contemporaneous, that they had been

formed at the same time. Huxley pointed out that the fact of identical fossils being present was, on the whole, evidence against the beds having been formed at the same time. Even some of the older writers who believed in species having been created at definite places at definite times had seen that time must have been required for sets of animals to wander from the places in which they had come into existence. The newer theory of evolution was equally opposed to the notion of the appearance of similar animals at the same time on far-distant parts of the earth. For such reasons he proposed to reject the use of the word *Contemporaneous* as applied to rockbeds in different localities which contained the same fossils, and to replace it by the word *Homotaxial*, which meant no more than that the beds occupied corresponding places in the geological history of the earth. Huxley did not pretend that these arguments were entirely original: they represented the drift of the best geological opinion, and he seized hold of them and set them down as permanent geological truths.

In 1869, in a Presidential Address to the Geological Society, Huxley took up one of the burning questions of the day. In the early part of the century, the discoveries of geologists had been the occasion of great distress to those good people who clung to a literal interpretation of everything in the Bible. Long before the doctrine of evolution and the descent of man from lower animals had taken practical shape, there had been a battle royal between geologists who declared that the earth was many million years old, and had been inhabited at least by animals and plants for enormous periods, and those who clung to the traditional chronology which placed the date of creation only a few thousand years from now. The continued progress of geology, and the sturdy championship of it by men like Sedgwick, Chalmers, and Buckland, who were at the same time reputable theologians and distinguished men of science, had decided the battle in favour of the conclusions of science, and it was accepted generally that the earth was almost

indefinitely old. At the same time, another and more strictly scientific dispute had been in progress. The older school of geologists, looking on the face of the world, and seeing it scarred by mighty fissures, displaying huge distortions of the beds in the crust, had argued that geological change had taken place by a series of mighty catastrophes. The tremendous results which they saw seemed to them only possible on the theory that unusual and gigantic displays of force had caused them. On the other hand, Hutton and Lyell attempted to find adequate explanation of the greatest changes in the slow forces which may be seen in operation at the present time. Slow movements of upheaval and depression, amounting at most to an inch or two in a century, may be shewn to be actually in existence now, and such slow changes acting for very many centuries would account for the raising of continents above the sea, so that old sea-bottoms became the surface of the land, and for the depression of land areas so that new sedimentary rocks might be deposited upon them. They shewed how air and water slowly crumbled away the hardest rocks, and how rivers deepened their beds steadily although slowly; and they held that while great catastrophic changes might occasionally have occurred, there was ample evidence of existing forces which, granted sufficient time for their operation, would have made the crust of the earth such as it is. This doctrine of *Uniformitarianism*, of the action of similar forces in the past and present history of the earth, had almost completely triumphed over the older catastrophic views. As Huxley put it, the school of catastrophe put no limit to the violence of forces which had operated; the uniformitarians put no limit to the length of time during which forces had operated.

"Catastrophism has insisted upon the existence of a practically unlimited bank of force, on which the theorist might draw; and it has cherished the idea of development of the earth from a state in which its form, and the forces which it exerted, were very different from those which we now know.

"Uniformitarianism, on the other hand, has with equal justice insisted upon a practically unlimited bank of time, ready to discount any quantity of hypothetical paper. It has kept before our eyes the power of the infinitely little, time being granted, and has compelled us to exhaust known causes before flying to the unknown."

But there was a third influence at work in geology, an influence which may best be described in Huxley's own words:

"I shall not make what I have to say on this head clear unless I diverge, or seem to diverge, for a while, from the direct path of my discourse so far as to explain what I take to be the scope of geology itself. I conceive geology to be the history of the earth, in precisely the same sense as biology is the history of living beings; and I trust you will not think that I am overpowered by the influence of a dominant pursuit if I say that I trace a close analogy between these two histories.

"If I study a living being, under what heads does the knowledge I obtain fall? I can learn its structure, or what we call its Anatomy; and its development, or the series of changes it passes through to acquire its complete structure. Then I find that the living being has certain powers resulting from its own activities, and the interaction of these with the activities of other things—the knowledge of which is Physiology. Beyond this, the living being has a position in space and time, which is its Distribution. All these form the body of ascertainable facts which constitute the *status quo* of the living creature. But these facts have their causes; and the ascertainment of these causes is the doctrine of Ætiology.

"If we consider what is knowable about the earth, we shall find that such earth-knowledge—if I may so translate the word geology—falls into the same categories.

"What is termed stratigraphical geology is neither more nor less than the anatomy of the earth; and the history of the succession of the formations is a history of the succession of such anatomies, or corresponds with development, as distinct from generation.

"The internal heat of the earth, the elevation and depression of its crust, its belching forth of vapours, ashes, and lava, are its activities, in as strict a sense as are warmth and the movements and products of respiration the activities of an animal. The phen-

omena of the seasons, of the trade-winds, of the Gulf Stream, are as much the results of the reaction between these inner activities and outward forces, as are the budding of the leaves in spring, and their falling in autumn the effects of the interaction between the organisation of a plant and the solar light and heat. And, as the study of the activities of the living being is called its physiology, so are these phenomena the subject matter of an analogous telluric physiology, to which we sometimes give the name of meteorology; sometimes of physical geography, sometimes that of geology. Again, the earth has a place in space and time, and relations to other bodies in both these respects, which constitute its distribution. This subject is usually left to the astronomer; but a knowledge of its broad outlines seems to me to be an essential constituent of the stock of geological ideas.

"All that can be ascertained concerning the structure, succession of conditions, actions, and position in space of the earth, is the matter of its natural history. But, as in Biology, there remains the matter of reasoning from these facts to their causes, which is just as much science as the other, and indeed more; and this constitutes geological ætiology.

"Having regard to this general scheme of geological knowledge and thought, it is obvious that geological speculation may be, so to speak, anatomical and developmental speculation, so far as it relates to points of stratigraphical arrangement which are out of reach of direct observation; or, it may be physiological speculation so far as it relates to undetermined problems relative to the activities of the earth; or, it may be distributional speculation, if it deals with modifications of the earth's place in space; or, finally, it will be ætiological speculation if it attempts to deduce the history of the world, as a whole, from the known properties of the matter of the earth, in the conditions in which the earth has been placed."

Huxley then proceeded to shew that uniformitarianism and catastrophism had neglected this last and most important branch of geology, the attempt to trace the interaction of causes which had brought the world into its present condition. He gave a striking display of the wide knowledge of his reading by going back to the foundation of this branch of modern science, and giving a masterly account of the then little-known treatise of Immanuel Kant, who in 1775 had written *An*

Attempt to Account for the Constitutional and Mechanical Origin of the Universe upon Newtonian Principles. Next he declared that evolution embraced all that was sound in both catastrophism and uniformitarianism while rejecting the arbitrary limits and assumptions of both.

Finally he came to the great question to which these observations upon the existing schools of geology had led. The most distinguished physicist of the age, then Sir William Thomson, afterwards Lord Kelvin, and Huxley's immediate successor in the Presidential Chair of the Royal Society, had stated that the English school of geology had assumed an impossible age for the earth. By physical reasonings, Thomson stated that he was able to prove that "the existing state of things on the earth—all geological history shewing continuity of life—must be limited within some such period of time as one hundred million years." This pronouncement had been received with acclamation by those who feared the geological and biological sciences, as a sign of internal dissensions within the house of science. Huxley, then, as all through the latter part of his life, at once constituted himself the champion of science, and, taking Thomson's arguments one by one, shewed by a series of masterly deductions from known facts that there was a great deal to be said for the other side, and that physicists were as little certain as geologists could be of the exact duration of time that had elapsed since the dawn of life. His plea for more time since the cooling of the globe than physicists were willing to allow remains one of the classics of geological literature. But he carried the question much farther. The inference which was widely drawn by the enemies of evolution from the arguments of Sir William Thomson was that if geologists had overestimated the age of the cooled earth there was not time for the evolution of animals and plants to have taken place. Huxley pointed out a fact which should be quite obvious, but which even yet is frequently neglected. The evidence for the gradual appearance of life in the

past history of the earth depends simply on the fact that the successive forms of life appear in successive strata, and the length of time taken for these changes simply depends upon the length of time which was taken up by the formation of the strata. Our only reason for supposing the evolution of life, made plain by fossil records, to have taken place very slowly is that geologists have stated that the deposition of the strata took place very slowly. Whether these strata were deposited slowly or less slowly, we know that the forms of life changed at the same rate.

"Biology takes her time from geology. The only reason we have for believing in the slow rate of change in living forms is the fact that they persist through a series of deposits which, geology informs us, have taken a long while to make. If the geological clock is wrong, all the naturalist will have to do is to modify his notion of the rapidity of change accordingly; and I venture to point out that, when we are told that the limitation of the period during which living beings have inhabited this planet to one, two, or three hundred million years requires a complete revolution in geological speculation, the *onus probandi* rests on the maker of the assertion, who brings forward not a shadow of evidence in its support."

Perhaps, although this is now an old controversy, it is worth while to recall that the keenness of Huxley's language was not directed against Sir William Thomson, between whom and Huxley there was no more than the desire to argue out an interesting scientific question upon which their conclusions differed, but between Huxley and those outsiders who were always ready to turn any dubious question in science into an argument discrediting the general conclusions of science.

The last time that Huxley occupied the Presidential Chair of the Geological Society was in 1870, and he devoted his Presidential address to a review of the "old judgments" which he had given in the course of his first address in 1862. The

address was entitled "Palæontology and Evolution," and the most important part of it was a complete withdrawal of the fears he had expressed that geology would not supply definite evidence of the transformation of species. Important discoveries had come thick and fast; and, at least in the case of the higher vertebrates, he declared that, however one might "sift and criticise them," they left a clear balance in favour of the doctrine of the evolution of living forms one from another. But, with his usual critical spirit, examining arguments that bore against a conclusion for which he hoped almost more stringently than arguments apparently favourable to what he expected to be true, Huxley made an important distinction, the value of which becomes more and more obvious as time goes on. In the first flush of enthusiasm for Darwinism, zoologists and palæontologists allowed their zeal to outrun discretion in the formation of family trees. They examined large series of living or extinct creatures, and as often as they found gradations of structure present, they arranged their specimens in a linear series, from the simplest to the most complex, and declared that the arrangement was a representation of the family tree. The fact that the line of descent plainly could have followed along a particular direction they were inclined to take as evidence that it actually had done so. Huxley made the most careful distinction between what he called intermediate types and types with a right to be placed in linear order.

"Every fossil which takes an intermediate place between forms of life already known may be said, so far as it is intermediate, to be evidence in favour of evolution, inasmuch as it shews a possible road by which evolution may have taken place. But the mere discovery of such a form does not, in itself, prove that evolution took place by and through it, nor does it constitute more than a presumptive evidence in favour of evolution in general." "The fact that *Anoplotheridæ* are intermediate between pigs and ruminants does not tell us whether the ruminants have come from the pigs or the pigs from the ruminants, or both from *Anoplotheridæ*, or whether pigs, ruminants, and

Anoplotheridæ alike may not have diverged from some common stock."

A familiar instance will make the point at issue plain. Everyone knows that in many respects, in the structure of the skeleton, and the curve of the backbone, and in the development of the brain, the man-like monkeys, the gorilla and its allies, are intermediate between man and the lower monkeys. In the early days of evolution it was assumed frequently that the gorilla, etc., were therefore to be regarded as ancestors of man, and they appear as such in more than one well-known treatise on evolutionary biology. We now know that it is exceedingly probable that the gorilla and its allies, although plainly intermediate types, and truly shewing a possible path of evolution from the brute to man, are not the actual ancestors of man, but cousins, descendants like man from some more or less remote common ancestor. And the tendency of recent advances in knowledge is more and more to throw stress on the value of Huxley's distinction, and to minimise confusion between "intermediate" and actual ancestral types.

CHAPTER VI

HUXLEY AND DARWIN

FROM our attempt to place together as much as possible of Huxley's geological work in the last chapter, it followed that we anticipated matter that falls properly within this chapter. The year 1859, the date of publication of *The Origin of Species,* is a momentous date in the history of the century, as it was the year in which there was given to the world a theory that not only revolutionised scientific opinion, but altered the trend of almost every branch of thought. To understand this great change, and the part played in it by Huxley, it is necessary to be quite clear as to what Darwin did. In the first place, he did not invent evolution. The idea that all the varied structures in the world, the divergent forms of rocks and minerals and crystals, the innumerable trees and herbs that cover the face of the earth like a mantle, and all the animal host of creatures great and small that dwell on the land or dart through the air or people the waters—that all these had arisen by natural laws from a primitive unformed material was known to the Greeks, was developed by the Romans, and even received the approval of early Christian Fathers, who wrote long before the idea had been invented that the naïve legends of the Old Testament were an authoritative and literal account of the origin of the world. After a long interval, in which scientific thought was stifled by theological dogmatism, the theory of evolution, particularly in its application to animals, began to reappear, even before Darwin published *The*

Origin of Species. Buffon, the great French naturalist, and Erasmus Darwin, the grandfather of Charles, had expressed in the clearest way the possibility that species had not been created independently, but had arisen from other species. Lamarck had worked out a theory of descent in the fullest detail, and regarded it as the foundation of the whole science of biology. He taught that the beginning of life consisted only of the simplest and lowest plants and animals; that the more complex animals and plants arose from these, and that even man himself had come from ape-like mammals. He held that the course of development of the earth and of all the creatures upon it was a slow and continuous change, uninterrupted by violent revolutions. He summed up the causes of organic evolution in the following propositions * :

"1. Life tends by its inherent forces to increase the volume of each living body and of all its parts up to a limit determined by its own needs.

"2. New wants in animals give rise to new movements which produce organs.

"3. The development of these organs is in proportion to their employment.

"4. New developments are transmitted to offspring."

He supported especially the last two propositions by a series of examples as to the effects of use and disuse; and the most famous of these, the theory that giraffes had produced their long necks by continually stretching up towards the trees on which they fed, is well known to everyone. However, the ingenious speculations of Lamarck were unsupported by a sufficient range of actual knowledge of anatomy, and lacked experimental proof. He entirely failed to convince his contemporaries; and Darwin himself, in a letter to Lyell, declared that he had gained nothing from two readings of Lamarck's book. There can be little

* See E. Clodd's *Pioneers of Evolution*, London, 1897, and Osborn's *From the Greeks to Darwin*, New York, 1896.

doubt but that several Continental writers, in particular Haeckel, have exaggerated Lamarck's services to the development of the idea of evolution. On the other hand, Lyell, although he strongly opposed the ideas of Lamarck and some curious notions of progressional creation due to the great Agassiz, had prepared the way for Darwin by his advocacy of natural causes and slow changes in opposition to the catastrophic and miraculous views in vogue. Above all, Herbert Spencer had argued most strenuously in favour of evolution. Thus, in an important passage quoted by Mr. Clodd from the *Leader* of March 20, 1852, Spencer had written as follows :

" Those who cavalierly reject the theory of evolution as not adequately supported by facts, seem quite to forget that their own theory is not supported by facts at all. Like the majority of men who are born to a given belief, they demand the most rigorous proof of any adverse belief, but assume that their own needs none. Here we find, scattered over the globe, vegetable and animal organisms numbering, of the one kind (according to Humboldt) some 320,000 species, and of the other, some 2,000,000 species (see Carpenter); and if to these we add the numbers of animal and vegetable species that have become extinct, we may safely estimate the number of species that have existed, and are existing, on the earth, at no less than ten millions. Well, which is the most rational theory about these ten millions of species? Is it most likely that there have been ten millions of special creations; or is it most likely that by continual modifications, due to change of circumstances, ten millions of varieties have been produced, as varieties are being produced still? . . . Even could the supporters of the development hypothesis merely shew that the origination of species by the process of modification is conceivable, they would be in a better position than their opponents. But they can do much more than this. They can shew that the process of modification has effected, and is effecting, decided changes in all organisms subject to modifying influences. . . . They can shew that in successive generations these changes continue, until ultimately the new conditions become the natural ones. They can shew that in cultivated plants, domesticated animals, and in the several races of men, such alterations have taken place. They can

shew that the degrees of difference so produced are often, as in dogs, greater than those on which distinctions of species have been founded. They can shew, too, that the changes daily taking place in ourselves—the facility that attends long practice, and the loss of aptitude that begins when practice ceases—the strengthening of the passions habitually gratified, and the weakening of those habitually curbed—the development of every faculty, bodily, moral, intellectual, according to the use made of it—are all explicable on this principle. And thus they can shew that throughout all organic nature there is at work a modifying influence of the kind they assign as the cause of these specific differences; an influence which, though slow in its action, does, in time, if the circumstances demand it, produce marked changes—an influence which, to all appearance, would produce in the millions of years, and under the great varieties of condition which geological records imply, any amount of change."

These and many other instances which might be brought together from the published writings of the half-century before the publication of the *Origin*, show conclusively that the idea of evolution was far from new, and that all through the first part of this century dissatisfaction with the doctrine of the fixity of species and of their miraculous creation was growing. The great contribution of Darwin was this: First, by his theory of natural selection, he brought together the known facts of variation, of struggle for existence, and of adaptation to varying conditions, in such a way that they provided us with a rational and known cause, a cause the operation of which could be seen, for the origin of species by means of preservation of favoured races. Next, as to the origin of species, he brought together not only proofs of the actual operation of natural selection, but a body of evidence in favour of the fact of evolution that was, beyond all comparison, more striking than had been adduced by any earlier philosophical or biological writer. He convinced naturalists that evolution was by far the most probable way in which the living world had come to be what it is, and he made them turn to examination of the

animal and vegetable kingdoms with a lively hope that the past history of the living world was not an insoluble problem. Darwin's doctrine brought a new life into biological study, and the result of the incomparably greater bulk of investigation that followed the year 1859 was a continual increase of evidence in favour of the probability of evolution, until now the whole scientific world, and the majority of those who are unscientific, are content to accept evolution as the only reasonable explanation of the living world. It is well to remember that while Darwin, by bringing forward the theory of struggle for existence and resulting survival of the fittest, was the actual cause of the present assured position of evolution as a first principle of science, it by no means follows that the survival of the fittest has become similarly a first principle of science. At cross-roads a traveller may choose the right path from a wrong reason. Darwin himself, in the act of bringing forward his own theory of natural selection, admitted the possibility of the co-operation of many other agencies in evolution, and at various times during the course of his life he was inclined to attach, now more now less, importance to these additional agencies. Huxley, as we shall soon come to see, never wavered in his adhesion to the facts of evolution after 1859; but, from first to last, regarded natural selection as only the most probable cause of the occurrence of evolution. Other naturalists, of whom the best-known are Weismann in Germany, Ray Lankester in England, and W. K. Brooks in America, came to attach a continually increasing importance to the purely Darwinian factor of natural selection; while others again, such as Herbert Spencer in England, and Cope and a large American school, advocated more and more strongly the importance of what may be called the Lamarckian factors of evolution—the inherited effects of increased or diminished use of organs, the direct influence of the environment, and so forth. From the fact that Darwin has persuaded the world of the truth of evolution, evolution is often called

Darwinism; and in this historically just though scientifically inaccurate sense of the term, Huxley was a strict Darwinian, a Darwinian of the Darwinians. From the facts that, although natural selection had been formulated by several writers before Darwin, and had been simultaneously elaborated by Wallace and Darwin, the *Origin of Species* was the foundation of the modern acceptation of evolution, and natural selection was the keynote of the origin of species, natural selection may be called Darwinism with both historical and scientific accuracy; and in this sense of the term Huxley was a Darwinian; a convinced but free-thinking and broad-minded Darwinian, who was far from persuaded that his tenet had a monopoly of truth, and who delighted in shewing the distinctions between what seemed to him probable and what was proved, and in absorbing from other doctrines whatever he thought worthy to be absorbed. The present writer has thought it so important to distinguish between these two sides of the word *Darwinism*, that for the sake of clearness he has stated what he believes to be the truth of Huxley's relation to Darwin before beginning detailed exposition of it.

In consideration of Huxley's position before 1859, the most interesting feature of his zoological work is the gradual preparation that it was making in his mind for the doctrine of the *Origin*. He was like an engineer boring a tunnel through a mountain, but ignorant of how near he was to the pleasant valley on the other side; and, above all, ignorant how rapidly he was being met by a much more mighty excavation from the other side. To use what is perhaps a more exact simile: he was like a child with half the pieces of a puzzle-map, slowly linking them together as far as they would fit, and quite ignorant that presently the remaining half would suddenly be given him, and with almost no trouble would at once fit into the gaps he had necessarily left, and transform a meaningless pattern into a perfect and intelligible whole. Let us consider some of these map pieces. The ulti-

mate picture was the conception of the whole world of life, past and present, as a single family tree growing up from the simplest possible roots, and gradually spreading out first into the two main branches of animals and plants, and then into the endless series of complicated ramifications that make up living and extinct animals and plants. Huxley was piecing together the scattered fragments, and gradually learning to see here and there whole branches, as yet separate at their lower ends, but in themselves shapely, and shewing a general resemblance to one another in the gradual progression from simple to complex. The greatest of these branches that he had pieced together was the group of Medusæ and their allies, now known as Cœlentera. He had formed similar branches for the Molluscs and minor branches for the Salps and Ascidians, and, in his general lectures on the whole animal kingdom, he had shadowed out the broad arrangement of the main divisions, or, as he called them, *types*. He had seen in each particular branch the clearest evidence of the laws of growth which had directed its development, and had realised that these laws of growth, consisting of gradual modifications of common typical structures, were identical in the different branches. He had taken clear hold of von Baer's conception that the younger stages of different types were more alike than the adult stages, and here and there he had made comparisons between the younger stages or simplest forms of his different branches, and had shewn that, without completely realising it, he was ready for the idea that just as the separate pieces could be arranged to form orderly branches, so the separate branches might come to be arranged as a single tree. And finally, in his lectures on "Protoplasm and Cells," and on the "Common Structure of the Animal and Plant Kingdoms," he had reached the conclusion that the two main divisions of the living world were formed of the same stuff, displayed the elementary functions of life in identical fashion, and were creatures of the same order. But, notwithstanding this close

approach to modern conceptions, he was not an evolutionist. When, in public, he expressed deliberate convictions, these were against the general idea of evolution, until just before 1859. In this opposition he was supported partly by the critical scepticism of his mind, which in all things made him unwilling to accept any theories of any kind, but chiefly from the fact that the books of the two chief supporters of evolutionary conceptions impressed him unfavourably. Huxley writes:

"I had studied Lamarck attentively, and I had read the *Vestiges* with due care; but neither of them afforded me any good ground for changing my negative and critical attitude. As for the *Vestiges*, I confess that the book simply irritated me by the prodigious ignorance and thoroughly unscientific habit of mind manifested by the writer. If it had any influence on me at all, it set me against evolution; and the only review I ever have qualms of conscience about, on the ground of needless savagery, is one I wrote on the *Vestiges* while under that influence. With respect to the *Philosophie Zoologique*, it is no reproach to Lamarck to say that the discussion of the species question in that work, whatever might be said for it in 1809, was miserably below the level of the knowledge of half a century later. In that interval of time, the elucidation of the structure of the lower animals and plants had given rise to wholly new conceptions of their relations; histology and embryology, in the modern sense, had been created; physiology had been reconstituted; the facts of distribution, geological and geographical, had been prodigiously multiplied and reduced to order. To any biologist whose studies had carried him beyond mere species-mongering, in 1850 one-half of Lamarck's arguments were obsolete, and the other half erroneous or defective, in virtue of omitting to deal with the various classes of evidence which had been brought to light since his time. Moreover his one suggestion as to the cause of the gradual modification of species—effort excited by change of conditions—was, on the face of it, inapplicable to the whole vegetable world. I do not think that any impartial judge who reads the *Philosophie Zoologique* now, and who afterwards takes up Lyell's trenchant and effective criticism (published as far back as 1830) will be disposed to allot to Lamarck a much higher place in

the establishment of biological evolution than that which Bacon assigns to himself in relation to physical science generally—*buccinator tantum*."

On the other hand, Huxley's friendship with Darwin and with Lyell began to make him less certain about the fixity of species. He tells us that during his first interview with Darwin, which occurred soon after his return from the *Rattlesnake*, he himself

"expressed his belief in the sharpness of the lines of demarcation between natural groups and in the absence of transitional forms, with all the confidence of youth and imperfect knowledge. I was not aware at that time that he had been many years brooding over the species question; and the humorous smile which accompanied his gentle answer, that such was not altogether his view, long haunted and puzzled me."

An elaborate study of Lyell's works helped largely in destroying this youthful confidence, and a letter written by Lyell and quoted by Huxley in the chapter he communicated to Darwin's *Life and Letters*, states that in April, 1856, "when Huxley, Hooker, and Wollaston were at Darwin's last week they (all four of them) ran a tilt against species; further I believe, than they are prepared to go." Another quotation from Huxley's essay on *The Reception of the Origin of Species* will make it plain beyond all doubt that he was not a Darwinian before Darwin.

"Thus, looking back into the past, it seems to me that my own position of critical expectancy was just and reasonable, and must have been taken up, on the same grounds, by many other persons. If Agassiz had told me that the forms of life which had successively tenanted the globe were the incarnations of successive thoughts of the Deity; and that He had wiped out one set of these embodiments by an appalling geological catastrophe as soon as His ideas took a more advanced shape, I found myself not only unable to admit the accuracy of the deductions from the facts of palæontology, upon which this astounding hypothesis

was founded, but I had to confess my want of means of testing the correctness of his explanation of them. And besides that, I could by no means see what the explanation explained. Neither did it help me to be told by an eminent anatomist that species had succeeded one another in time, in virtue of a 'continuously operative creational law.' That seemed to me to be no more than saying that species had succeeded one another in the form of a vote-catching resolution, with 'law' to please the man of science and 'creational' to draw the orthodox. So I took refuge in that *thätige Skepsis* which Goethe had so well defined; and, reversing the apostolic precept to be all things to all men, I usually defended the tenability of the received doctrines when I had to do with the transmutationists, and stood up for the possibility of transmutation among the orthodox—thereby, no doubt, increasing an already current, but quite undeserved, reputation for needless combativeness."

What transformed Huxley's views and the views of his contemporaries who accepted Darwinism was not so much the evidence in favour of evolution contained in the *Origin*, as the illuminating doctrine of natural selection which for the first time supplied naturalists with a reasonable explanation of how evolution might have come about, both in the animal and vegetable kingdoms. As soon as this reason was provided them, they turned to the store of facts within their own knowledge, and rapidly arranged the evidence in favour of the fact of evolution which had been lurking only partly visible. It cannot be disputed that here and there earlier writers than Darwin and Wallace had suggested the possibility of natural selection acting upon existing variations so as to cause survival of the fittest. The older MacGillivray had published suggestions which came exceedingly near to Darwin's theory. In 1831 Patrick Matthew had published a work on *Naval Architecture and Timber*, and in it had stated the essential principle of the Darwinian doctrine of struggle and survival. Still earlier, in 1813, a Dr. W. C. Wells, in a paper to the Royal Society on "A White Female, Part of whose Skin Resembles that of a Negro," had, as Darwin himself freely admitted, distinctly recog-

nised the principle of natural selection—but applied it only to the races of man, and to certain characters alone. Finally, long before either of these, Aristotle himself had written, in *Physics*, ii. 8: "Why are not the things which seem the result of design, merely spontaneous variations, which, being useful, have been preserved, while others are continually eliminated as unsuitable?" These foreshadowings were not supported by lengthy evidence, nor worked out into an elaborate theory; and it was not until Darwin had done this that we can say the birth of natural selection really took place. Huxley writes:

"The suggestion that new species may result from the selective action of external conditions upon the variations from their specific type which individuals present—and which we call 'spontaneous,' because we are ignorant of their causation—is as wholly unknown to the historian of scientific ideas as it was to biological specialists before 1858."

But that suggestion is the central idea of the origin of species, and contains the quintessence of Darwinism.

Long before the *Origin of Species* was published, Huxley had become an intimate personal friend of Darwin, and understood something of the vast insight and knowledge that lay behind Darwin's gentle, unassuming manner. In 1851, about a year after his return from the *Rattlesnake*, Huxley had met, studied and *placed* the leading English zoologists, ("Life and Letters," I. p. 94). Owen he thought the "most superior of all," but added, "He does not conceal that he knows it, and it must be confessed that he does some very ill-natured tricks now and then." "Owen is an able man, but to my mind not so great as he thinks himself." Edward Forbes he regarded as the other leader of zoological science in England. "More especially as a zoologist and geologist than a comparative anatomist, he has more claims to the title of a philosophic naturalist than any man I know of in England." "Forbes has more influence by his personal weight and example upon the rising genera-

tion of scientific naturalists than Owen will have if he write from now until Domesday."

"The rest of the naturalists stand far below these two in learning, originality and grasp of mind." "Darwin might be anything, if he had good health."

Forbes died in 1853, long before the publication of the *Origin*. Owen acted almost precisely in accordance with Huxley's early judgment of him, and Darwin's health was anyhow good enough for something!

Some weeks before the *Origin* was published, Darwin wrote to Huxley, sending him a copy of the work, and asking him for the names of eminent foreigners to whom it should be sent. In the course of his letter he wrote: "I shall be intensely curious to hear what effect the book produces on you," and it was clear that he had no very confident expectation of a favourable opinion. Huxley replied the day before the *Origin* was published, saying that he had finished the volume, and stating that it had completely convinced him of the fact of evolution, and that he fully accepted natural selection as a "true cause for the production of species." Darwin, in a letter to Wallace, telling him of his doubts and fears concerning the reception of his book, had added the postscript: "I think I told you before that Hooker is a complete convert. If I can convert Huxley, I shall be content." When he received Huxley's letter he replied at once:

"Like a good Catholic who has received extreme unction, I can now sing *Nunc Dimittis*. I should have been more than contented with one quarter of what you have said. Exactly fifteen months ago, when I first put pen to paper for this volume, I had awful misgivings, and thought perhaps I had deluded myself, like so many have done; and I then fixed in my mind three judges, on whose decision I determined mentally to abide. The judges were Lyell, Hooker, and yourself. It was this which made me so excessively anxious for your verdict. I am now contented, and can sing my *Nunc Dimittis*."

The effect of the new theory on Huxley's mind

has been expressed most fully and clearly by himself:

"I imagine that most of my contemporaries who thought seriously about the matter were very much in my own state of mind—inclined to say to Mosaists and Evolutionists, 'a plague on both your houses!' and disposed to turn aside from an interminable and apparently fruitless discussion to labour in the fertile fields of ascertainable fact. And I may, therefore, further suppose that the publication of the Darwin and Wallace papers in 1858, and still more that of the *Origin* in 1859, had the effect upon them of that of a flash of light which, to a man who has lost himself in a dark night, suddenly reveals a road which, whether it takes him straight home or not, certainly goes his way. That which we were looking for, and could not find, was a hypothesis respecting the origin of known organic forms, which assumed the operation of no causes but such as could be proved to be actually at work. We wanted, not to pin our faith to that or any other speculation, but to get hold of clear and definite conceptions which could be brought face to face with facts and have their validity tested. The *Origin* provided us with the working hypothesis we sought. Moreover, it did us the immense service of freeing us for ever from the dilemma—refuse to accept the creation hypothesis, and what have you to propose that can be accepted by any cautious reasoner? In 1857 I had no answer ready, and I do not think that anyone else had. A year later, we reproached ourselves with dullness for being perplexed by such an enquiry. My reflection, when I first made myself master of the central idea of the *Origin* was, 'how exceedingly stupid not to have thought of that.' I suppose that Columbus's companions said much the same when he made the egg to stand on end. The facts of variability, of the struggle for existence, of adaptation to conditions, were notorious enough; but none of us had suspected that the road to the heart of the species problem lay through them, until Darwin and Wallace dispelled the darkness, and the beacon-fire of the *Origin* guided the benighted.

"Whether the particular shape which the doctrine of evolution, as applied to the organic world, took in Darwin's hands, would prove to be final or not, was, to me, a matter of indifference. In my earliest criticisms of the *Origin* I ventured to point out that its logical foundation was insecure so long as

experiments in selective breeding had not produced varieties which were more or less infertile; and that insecurity remains up to the present time. But, with any and every critical doubt which my sceptical ingenuity could suggest, the Darwinian hypothesis remained incomparably more probable than the creation hypothesis. And if we had none of us been able to discern the paramount significance of some of the most patent and notorious of natural facts, until they were, so to speak, thrust under our noses, what force remained in the dilemma—creation or nothing? It was obvious that, hereafter, the probability would be immensely greater that the links of natural causation were hidden from our purblind eyes, than that natural causation should be unable to produce all the phenomena of nature. The only rational course for those who had no other object than the attainment of truth, was to accept 'Darwinism' as a working hypothesis, and see what could be made of it. Either it would prove its capacity to elucidate the fact of organic life, or it would break down under the strain. This was surely the dictate of common sense, and for once common sense carried the day. The result has been that complete *volte-face* of the whole scientific world which must seem so surprising to the present generation. I do not mean to say that all the leaders of biological science have avowed themselves Darwinians; but I do not think that there is a single zoologist, or botanist, or palæontologist, among the multitude of active workers of this generation, who is other than an evolutionist profoundly influenced by Darwin's views. Whatever may be the ultimate fate of the particular theory put forth by Darwin, I venture to affirm that, so far as my knowledge goes, all the ingenuity and all the learning of hostile critics has not enabled them to adduce a solitary fact of which it can be said that it is irreconcilable with the Darwinian theory. In the prodigious variety and complexity of organic nature, there are multitudes of phenomena which are not deducible from any generalisation we have yet reached. But the same may be said of every other class of natural objects. I believe that astronomers cannot yet get the moon's motions into perfect accordance with the theory of gravitation."

These quotations establish the historical fact that Huxley was convinced of evolution because Darwin, by his theory of natural selection, brought

forward an actual cause that could be seen in operation, and that was competent to produce new species. As soon as the "flash of light" came, it revealed to Huxley the vast store of evidence that he had unconsciously accumulated, and it set him at once to work collecting more evidence. If we bear in mind the distinction between evolution and natural selection, the subsequent history of the relations between Huxley and what was known popularly as Darwinism becomes clear and intelligible. From first to last he accepted evolution; from first to last he accepted natural selection as by far the most reasonable hypothesis that had been brought forward, and as infinitely more in accordance with the observed facts of nature than any theory of the immediate action of supernatural creative power. As time went on, and the influence of Darwin's theory made evolution acceptable to a wider and wider range of people, until it passed into the common knowledge of the world, that confusion of which I have spoken arose between evolution and Darwin's particular theory. And as knowledge grew, and the number of biologists increased in the striking fashion of the latter half of the nineteenth century, while the evidence for evolution continued to increase with an unexpected rapidity, every detail of the purely Darwinian theory became more and more subjected to rigid scrutiny. Most educated people, unless their education has been largely in an experimental science, find difficulty in understanding the relation in the minds of naturalists between "authority" and "knowledge." We do not *know*, for instance, that the structure of the Medusæ consists essentially of two foundation-membranes, because Huxley, one of the greatest authorities in anatomy that the world has seen, told us that it was so. We know it because, Huxley having told us that it was so, we are able at any time with a microscope and dissecting needles to observe the fact for ourselves. It is true, that unless we are making a special study of the Medusæ we do not repeat the observation in the case of so many

different forms of Medusæ as Huxley studied; but it is part of our training to observe for ourselves in a sufficient number of cases to test the correspondence between statement and fact before we accept the generalisation of any authority. And we learn, or at least have the opportunity of learning, in the whole habit of our lives as naturalists, to distinguish carefully between knowledge of which personal observation is an essential part, and opinion or belief which may or may not be based upon authority, but which in any case is devoid of the corroboration of personal observation. When a piece of new anatomical or physiological work is published in a technical journal, it is read by a number of anatomists and physiologists, and if the work is apparently of an important kind, bearing on the general problems that even specialists have to follow, they all at once set to work in their laboratories to make corroborative dissections or experiments, and it is part of every modern account of a biological discovery to tell exactly the methods by which results were got, in order that this process of corroboration may be set about easily. The question as to whether or no natural selection were the sole or chief cause, or indeed a cause at all, of evolution is not yet, and perhaps never will be, a matter of knowledge in the scientific sense. At the most, we can see for ourselves only that selection does bring about changes at least as great as the differences between natural species. The evidence for this we have before our eyes, if we choose to see, on a stock farm; in the breeding yards of any keeper of "fancy" animals; or in the nursery gardens of any florist. So far, Huxley accepted the Darwinian principle as a definite contribution to knowledge; and so far the whole body of biologists has followed him. Beyond this the truth of the Darwinian principle is a matter of inference or judgment; of balancing probabilities and improbabilities. In multitude of counsellors there is said to be wisdom, and what we learn from the counsellors of biology all over the world is that some maintain that natural selection

is the only probable agency in effecting evolution, and that it is competent to account for all the changes which we know to have taken place; others hold that its probable influence has been overrated; and others, again, think that it has been one of the many causes that have brought about the kaleidoscopic variety of organic nature. Huxley remained to the last among those who distinguished in the clearest way between natural selection as an exceedingly ingenious and probable hypothesis, and a proved cause; and he was always careful, especially when he was writing for or speaking in the presence of those who like himself accepted the fact of evolution as proven, to distinguish between this provisional hypothesis as to how evolution had come about, and definite knowledge that it had come about in this way. Two passages from Huxley's writings, one written in 1860 in the *Westminster Review*, and the second written in 1893, in the preface to the volume of his collected essays which contained a reprint of the *Westminster* article, will make plain the continuity of Huxley's attitude:

"There is no fault to be found with Mr. Darwin's method, then; but it is another question whether he has fulfilled all the conditions imposed by that method. Is it satisfactorily proved, in fact, that species may be originated by selection? That there is such a thing as natural selection? That none of the phenomena exhibited by species are inconsistent with the origin of species in this way? If these questions can be answered in the affirmative, Mr. Darwin's view steps out of the rank of hypotheses into that of proved theories; but, so long as the evidence at present adduced falls short of enforcing that affirmation, so long, to our minds, must the new doctrine be content to remain among the former—an extremely valuable, and in the highest degree probable, doctrine; indeed, the only extant hypothesis which is worth anything in a scientific point of view; but still a hypothesis, and not yet the theory of species.

"After much consideration, and assuredly with no bias against Mr. Darwin's views, it is our clear conviction that, as the evidence stands, it is not absolutely

proven that a group of animals having all the characters exhibited by species in nature, has ever been originated by selection, whether natural or artificial. Groups having the morphological character of species, distinct and permanent races, in fact, have been so produced over and over again; but there is no positive evidence at present that any group of animals has, by variation and selective breeding, given rise to another group which was in the least degree infertile with the first. Mr. Darwin is perfectly aware of this weak point, and brings forward a multitude of ingenious and important arguments to diminish the force of the objection. We admit the value of these arguments to the fullest extent; nay, we will go so far as to express our belief that experiments, conducted by a skilful physiologist would very probably obtain the desired production of mutually more or less infertile breeds from a common stock in a comparatively few years; but still, as the case stands at present, this little 'rift within the lute' is not to be disguised or overlooked."—(*Westminster Review*, 1860.)

"We should leave a very wrong impression on the reader's mind if we permitted him to suppose that the value of Darwin's work depends wholly on the ultimate justification of the theoretical views which it contains. On the contrary, if they were disproved to-morrow, the book would still be the best of its kind—the most compendious statement of well-sifted facts bearing on the doctrine of species that has ever appeared. The chapters on variation, on the struggle for existence, on instinct, on hybridism, on the imperfection of the geological record, on geographical distribution, have not only no equals, but, so far as our knowledge goes, no competitors, within the range of biological literature. And viewed as a whole, we do not believe that, since the publication of von Baer's *Researches on Development*, thirty years ago, any work has appeared calculated to exert so large an influence, not only on the future of biology, but in extending the domination of science over regions of thought into which she has, as yet, hardly penetrated."—(*Ibid.*)

"Those who take the trouble to read the essays published in 1859 and 1860, will, I think, do me the justice to admit that my zeal to secure fair play for Mr. Darwin did not drive me into the position of a mere advocate; and that, while doing justice to the greatness of the argument, I did not fail to indicate its weak points. I have never seen any reason for

departing from the position which I took up in these two essays; and the assertion which I sometimes meet with nowadays that I have 'recanted' or changed my opinions about Mr. Darwin's views is quite unintelligible to me.

"As I have said in the seventh essay, the fact of evolution is to my mind sufficiently evidenced by palæontology; and I remain of the opinion expressed in the second, that until selective breeding is definitely proved to give rise to varieties infertile with one another, the logical foundation of the theory of natural selecton is quite incomplete. We still remain very much in the dark about the causes of variation; the apparent inheritance of acquired characters in some cases; and the struggle for existence within the organism, which probably lies at the bottom of both these phenomena."—(1893, *Preface.*)

Finally, when he was awarded the Darwin Medal of the Royal Society, on November 30, 1894, in the course of an address at the anniversary dinner of the Society, he said, as reported in the *Times* next day:

"I am as much convinced now as I was thirty-four years ago that the theory propounded by Mr. Darwin, I mean that which he propounded—not that which has been reported to be his by too many ill-instructed, both friends and foes—has never yet been shewn to be inconsistent with any positive observations, and if I may use a phrase which I know has been objected to, and which I use in a totally different sense from that in which it was first proposed by its first propounder, I do believe that on all grounds of pure science it 'holds the field' as the only hypothesis at present before us which has a sound scientific foundation. . . . I am sincerely of opinion that the views which were propounded by Mr. Darwin thirty-four years ago may be understood hereafter as constituting an epoch in the intellectual history of the human race. They will modify the whole system of our thought and opinion, our most intimate convictions. But I do not know, I do not think anybody knows, whether the particular views he held will be hereafter fortified by the experience of the ages which come after us. . . . Whether the particular form in which he has put before us the Darwinian doctrines may be such as to be destined to survive or not, is more, I venture

to think, than anybody is capable at this present moment of saying."

Further details of Huxley's relation to natural selection may be gained from an interesting chapter in Professor Poulton's volume on *Charles Darwin* (Cassel and Co., London, 1896).

CHAPTER VII

THE BATTLE FOR EVOLUTION

WHEN Huxley wrote thanking Darwin for the first copy of the *Origin*, he warned him of the annoyance and abuse he might expect from those whose opinions were too suddenly disturbed by the new exposition of evolution, and assured him of the strongest personal support:

"I trust you will not allow yourself to be in any way disgusted or annoyed by the considerable abuse and misrepresentation which, unless I greatly mistake, is in store for you. Depend upon it, you have earned the lasting gratitude of all thoughtful men; and as to the curs which will bark and yelp, you must recollect that some of your friends, at any rate, are endowed with an amount of combativeness which (though you have often and justly rebuked it) may stand you in good stead.

"I am sharpening my claws and beak in readiness."

Huxley was right in his prediction as to the magnitude of the prejudices to be overcome before evolution became accepted, and for the next thirty years of his life he was the leader in the battle for Darwinism. It was natural that the new views, especially in their extension to man himself, should arouse the keenest opposition. To those of the present generation, who have grown up in an atmosphere impregnated by the doctrine of descent, the position of the world in 1860 seems "older than a tale written in any book." As I have tried to shew in the preceding chapter, biological science was partially prepared; the mutability of species and the orderly succession of organic life were in the

air. But the application of the doctrine to man came as a greater shock to civilised sentiment than would have occurred a century earlier. It came as a disaster even to the clearest and calmest intellects, for it seemed to drag down to the dirt the nobility of man. Out of the fierce flame of the French Revolution, there had come purged and clean the conception of man as an individual and soul. As the nineteenth century advanced, the conception of the dignity and worth of each individual man, rich or poor, bound or free, had spread more and more widely, bearing as its fruit the emancipation of slaves, the spread of political freedom, the amelioration of the conditions of the dregs of humanity, the right of all to education, the possibility of universal peace based on the brotherhood of man; and all that was best in philosophy and in political practice seemed bound up with a lofty view of the unit of mankind. Carlyle himself, to whom many of the freest and noblest spirits in Europe were beginning to look as to an inspired prophet, could see in it nothing but a "monkey damnification of mankind." The dogmatic world saw in it nothing but a deliberate and malicious assault upon religion. The Church of England in particular was beginning to recover from a long period of almost incredible supineness, and there was arising a large body of clergy full of faith and zeal and good works, but ignorant of science, who frankly regarded Darwin as Antichrist, and Huxley and Tyndall as emissaries of the devil. Against evolutionists there was left unused no weapon that ignorant prejudice could find, whether that prejudice was inspired by a lofty zeal for what it conceived to be the highest interests of humanity, or by a crafty policy which saw in the new doctrine a blow to the coming renewed supremacy of the Church. To us, now, it may seem that Huxley had "sharpened his beak and claws" with the spirit of a gladiator rather than with that of the mere defender of a scientific doctrine; but a very short study of contemporary literature will convince anyone that for a time the defenders of

evolution had to defend not only what they knew to be scientific truth, but their personal and private reputations. The new doctrine, like perhaps all the great doctrines that have come into the world, brought not peace but a sword, and had to be defended by the sword. Darwin had not the kind of disposition nor the particular faculties necessary for a deadly contest of this kind; he was interested indeed above all things in convincing a few leading naturalists of the truth of his opinions; but, that done, he would have been content to continue his own work quietly, in absolute carelessness as to what the world in general thought of him. Huxley, on the other hand, was incapable of restraining himself from propagating what he knew to be the truth; his reforming missionary spirit was not content simply with self-defence; it drove him to be a bishop *in partibus infidelium*.

By a curious and interesting accident, Huxley had the opportunity of beginning his propagandism by writing the first great review of *The Origin of Species* in the *Times*, at that period without question the leading journal in the world. Huxley's own account of this happy chance is given in *Darwin's Life and Letters*, vol. ii.

"The *Origin* was sent to Mr. Lucas, one of the staff of the *Times* writers at that day, in what I suppose was the ordinary course of business. Mr. Lucas, though an excellent journalist, and at a later period editor of *Once a week*, was as innocent of any knowledge of science as a babe, and bewailed himself to an acquaintance on having to deal with such a book, whereupon he was recommended to ask me to get him out of his difficulty, and he applied to me accordingly, explaining, however, that it would be necessary for him formally to adopt anything I might be disposed to write, by prefacing it with two or three paragraphs of his own.

"I was too anxious to seize on the opportunity thus offered of giving the book a fair chance with the multitudinous readers of the *Times* to make any difficulty about conditions; and being then very full of the subject, I wrote the article faster, I think, than I ever wrote anything in my life, and sent it to Mr. Lucas, who duly prefixed his opening sentences.

When the article appeared, there was much speculation as to its authorship. The secret leaked out in time, as all secrets will, but not by my aid; and then I used to derive a good deal of innocent amusement from the vehement assertions of some of my more acute friends, that they knew it was mine from the first paragraph." "As the *Times* some years since referred to my connection with the review, I suppose there will be no breach of confidence in the publi cation of this little history."

This review was one of the few favourable notices, and naturally it delighted Darwin greatly. He wrote to Hooker about it: "Have you seen the splendid essay and notice of my book in the *Times*? I cannot avoid a strong suspicion that it is by Huxley; but I have never heard that he wrote in the *Times*. It will do grand service." On the same day, writing to Huxley himself, he said of the review:

"It included an eulogium of me which quite touched me, although I am not vain enough to think it all deserved. The author is a literary man and a German scholar. He has read my book attentively; but, what is very remarkable, it seems that he is a profound naturalist. He knows my barnacle book and appreciates it too highly. Lastly, he writes and thinks with quite uncommon force and clearness; and, what is even still rarer, his writing is seasoned with most pleasant wit. We all laughed heartily over some of the sentences. . . . Who can it be? Certainly I should have said that there was only one man in England who could have written this essay, and that you were the man; but I suppose that I am wrong, and that there is some hidden genius of great calibre; for how could you influence Jupiter Olympus and make him give you three and a half columns to pure science? The old fogies will think the world will come to an end. Well, whoever the man is, he has done great service to the cause."

The essay in the *Times* was followed shortly afterwards by a "Friday Evening Discourse" in 1860 on "Species, Races, and their Origin," in which Huxley, addressing a cultivated audience, laid the whole weight of his brilliant scientific reputa-

tion on the side of evolution. Next, in April, 1860, he published a long article in the *Westminster Review*, then a leading organ of advanced opinion, on *The Origin of Species*, some quotations from which article were made in the last chapter. Apart from its strong support of the doctrine of evolution, its whole-hearted praise of Darwin's achievements, and the clear way in which, while it shewed the value of natural selection as the only satisfactory hypothesis in the field, it gave reasons for regarding it strictly as an hypothesis, the review is specially interesting as a contrast to essays which appeared about the same time in the *Edinburgh Review* and in the *Quarterly*. Both these were not only exceedingly unfavourable, but were written in a spirit of personal abuse unworthy of their authors and still more of their subject. The review in the *Edinburgh* had come as a particularly great shock to Darwin, Huxley, and their friends. Sir Richard Owen, in many ways, was at that time the most distinguished anatomist in England. He had been an ardent follower of Cuvier, and in England had carried on the palæontological work of the great Frenchman. He was a personal friend of the court, a well-known man in the best society, and in many ways a worthy upholder of the best traditions of science. In the particular matter of species, he was known to be by no means a firm supporter of the orthodox views. When Darwin's paper was read at the Linnæan Society, and afterwards when the *Origin* was published, the verdict of Owen was looked to with the greatest interest by the general public. For a time he wavered, and even expressed himself of the opinion that he had already in his published works included a considerable portion of Darwin's views. But two things seemed to have influenced him: First, Wilberforce, the Bishop of Oxford, and Sedgwick and Whewell, the two best-known men at Cambridge, urged him to stamp once for all, as he only could do, upon this "new and pernicious doctrine." Secondly, combined with his great abilities, he had the keenest personal interest in his own position as the leader of English science,

and had no particular friendship for men or for views that seemed likely to threaten his own supreme position. In a very short time he changed from being neutral, with a tendency in favour of the new views, to being a bitter opponent of them. In scientific societies and in London generally, naturally enough he constantly came across the younger scientific men, such as Huxley and Hooker, who had declared for Darwin, and he made the irretrievable mistake of attempting for a time to disguise his opposition while he was writing the most bitter of all the articles against Darwinism. That appeared in the *Edinburgh Review* in April, 1860, and the range of knowledge it displayed, and the form of arguments employed, naturally enough betrayed the secret of its authorship, although Owen for very long attempted to conceal his connection with it. Darwin, who had the most unusual generosity towards his opponents, found this review too much for him. Writing to Lyell soon after its publication, he said :

"I have just read the *Edinburgh*, which without doubt is by ——. It is extremely malignant, clever, and, I fear, will be very damaging. He is atrociously severe on Huxley's lecture, and very bitter against Hooker. So we three *enjoyed* it together. Not that I really enjoyed it, for it made me uncomfortable for one night; but I have quite got over it to-day. It requires much study to appreciate all the bitter spite of many of the remarks against me; indeed I did not discover all myself. It scandalously misrepresents many parts. He misquotes some passages, altering words within inverted commas. . . . It is painful to be hated in the intense degree with which —— hates me."

As Owen was still alive when this letter was published in *Darwin's Life*, the authorship of the review was not actually mentioned; but it is necessary to mention it, as it justifies the sternness with which Huxley exposed Owen on an occasion shortly to be described. The review in the *Quarterly* was written by Wilberforce, the Bishop of Oxford, in July, 1860, and almost at once the authorship of it became known to Darwin's friends.

In connection with this, Huxley wrote in 1887, in *Darwin's Life and Letters*:

"I doubt if there was any man then living who had a better right (than Darwin) to expect that anything he might choose to say on such a question as the Origin of Species would be listened to with profound attention, and discussed with respect. And there was certainly no man whose personal character should have afforded a better safeguard against attacks, instinct with malignity and spiced with shameless impertinences. Yet such was the portion of one of the kindest and truest men that it was ever my good fortune to know; and years had to pass away before misrepresentation, ridicule, and denunciation ceased to be the most notable constituents of the majority of the multitudinous criticisms of his work which poured from the press. I am loath to rake up any of these ancient scandals from their well-deserved oblivion; but I must make good a statement which may seem overcharged to the present generation, and there is no *pièce justificative* more apt for the purpose or more worthy of such dishonour than the article in the *Quarterly Review* for July, 1860. Since Lord Brougham assailed Dr. Young, the world has seen no such specimen of the insolence of a shallow pretender to a master in science as this remarkable production, in which one of the most exact of observers, most cautious of reasoners, and most candid of expositors, of this or any other age, is held up to scorn as a 'flighty' person who endeavours to 'prop up his utterly rotten fabric of guess and speculation,' and whose 'mode of dealing with nature' is reprobated as 'utterly dishonourable to natural science.' And all this high and mighty talk, which would have been indecent in one of Mr. Darwin's equals, proceeds from a writer whose want of intelligence, or of conscience, or of both, is so great, that, by way of an objection to Mr. Darwin's views, he can ask, 'Is it credible that all favourable varieties of turnips are tending to become men?' who is so ignorant of palæontology that he can talk of the 'flowers and fruits' of the plants of the carboniferous epoch; of comparative anatomy, that he can gravely affirm the poison apparatus of venomous snakes to be 'entirely separate from the ordinary laws of animal life, and peculiar to themselves'; of the rudiments of physiology, that he can ask, 'what advantage of life could alter the shape of the corpuscles into which the blood can be

evaporated?' Nor does the reviewer fail to flavour this outpouring of incapacity with a little stimulation of the *odium theologicum*. Some inkling of the history of the conflicts between astronomy, geology, and theology leads him to keep a retreat open by the proviso that he cannot 'consent to test the truth of Natural Science by the Word of Revelation,' but for all that he devotes pages to the exposition of his conviction that Mr. Darwin's theory 'contradicts the revealed relation of the creation to its Creator,' and is 'inconsistent with the fullness of His glory.'"

In a footnote to this passage, Huxley wrote that he was not aware when writing these lines that the authorship of the article had been avowed publicly. He adds, however:

"Confession unaccompanied by penitence, however, affords no ground for mitigation of judgment; and the kindliness with which Mr. Darwin speaks of his assailant, Bishop Wilberforce, is so striking an exemplification of his singular gentleness and modesty, that it rather increases one's indignation against the presumption of his critic."

As a matter of fact Wilberforce was a man of no particular information in letters or in philosophy, and his knowledge of science was a little natural history picked up from Gosse, the naturalist of the seashore, in the course of a few days' casual acquaintance at the seaside, and some pieces of anatomical facts with which he was provided, it is supposed, by Owen, for the purposes of the review. But he bore a great name, and abused a great position; he was a man of facile intelligence, smooth, crafty, and popular, and in this case he was convinced that he was doing the best possible for the great interests of religion by authoritatively denouncing a man whose character he was incapable of realising, and on whose work he was incompetent to pronounce an opinion. Against an enemy of this kind, Huxley was implacable and relentless. He was constitutionally incapable of tolerating pretentious ignorance, and he had realised from the first that there could be no question of giving and taking quarter from persons who were more con-

cerned to suppress doctrines they conceived to be dangerous than to examine into their truth. On the other hand, much as Huxley disliked Owen's devious ways, and although in after life there occurred many and severe differences of opinion between Huxley and Owen, Huxley had a sincere respect for much of Owen's anatomical and palæontological work, and when, in 1894, Owen's *Life* was published, one of the most interesting parts of it was a long, fair, and appreciative review by Huxley of Owen's contributions to knowledge.

It must be said, however, that Huxley fully appreciated the humour and the difficulty of the position. He had no high opinion of Owen, as a man, or as a man of science. As he wrote, trying to be more than fair, he realised fully that Owen had been vanquished in all the points he tried to make against Darwinism; vanquished so completely that the whole interest had gone out of any account of the struggle. "I am toiling over my chapter about Owen" he wrote to Hooker in 1894 ("Life and Letters," II. p. 373), "and I believe his ghost in Hades is grinning over my difficulties. The thing that strikes me most is, how he and I and all the things we fought about belong to antiquity."

The middle of 1860, however, was not a time for Huxley, in his capacity as Darwin's chief defender, to make truce with the enemy. In England a certain number of well-known scientific men had given a general support to Darwinism. From France, Germany, and America there had come some support and a good deal of cold criticism, but most people were simmering with disturbed emotions. The newspapers and the reviews were full of the new subject; political speeches and sermons were filled with allusions to it. Wherever educated people talked the conversation came round to the question of evolution. Were animals and plants the results of special creations, or were they, including man, the result of the gradual transformations of a few simple primitive types evolving under the stress of some such force as Darwin's natural

selection? To many people it seemed to be a choice between a world with God and a world without God; and the accredited defenders of religion gathered every force of argument, of misrepresentation, conscious and unconscious, of respectability, and of prejudice to crush once for all the obnoxious doctrine and its obnoxious supporters. In the autumn of that year it fell that the meeting of the British Association, then coming into prominence as the annual parliament of the sciences, was to be held at Oxford. It was inevitable that evolution should be debated formally and informally in the sessions of the Association, and it must have seemed to the orthodox that there, in that beautiful city, its air vibrant with tinkling calls to faith, its halls and libraries crowded with the devout and the learned, its history and traditions alike calling on all to defend the old fair piety, in such an uncongenial air, the supporters of evolution must be overwhelmed. Almost the whole weight of the attack had to be resisted by Huxley. In the various sectional meetings he had combat after combat with professors and clerics. Of these dialectic fights the most notable were one with Owen on the anatomical structure of the brain, and another with Wilberforce upon the general question of evolution. Owen contended that there were anatomical differences not merely of degree but of kind between the brain of man and the brain of the highest ape, and his remarks were accepted by the audience as a complete and authoritative blow to the theory of descent. Huxley at once met Owen with a direct and flat contradiction, and pledged his reputation to justify his contradiction with all due detail on a further occasion. As a matter of fact, he did justify the contradiction, and no anatomist would now dream of attempting the support of the proposition rashly made by Owen; but, at the time, the position of Owen and the sympathies of the audience took away much of their effect from Huxley's words. Two days later, Wilberforce, in a scene of considerable excitement, made a long, eloquent, and declamatory speech against evolution

and against Huxley. From the incomplete reports of the debate that were published, it is difficult to gain a very clear idea of the Bishop's speech; but it is certain that it was eloquent and facile, and that it appealed strongly to the religious prejudices of the majority of the audience. He ended by a gibe which, under ordinary circumstances, might have passed simply as the rude humour of a popular orator, but which in that electric atmosphere stung Huxley into a retort that has became historical. He asked Huxley whether he was related by his grandfather's or grandmother's side to an ape. Huxley replied:

"I asserted, and I repeat, that a man has no reason to be ashamed of having an ape for his grandfather. If there were an ancestor whom I should feel shame in recalling, it would be a *man*, a man of restless and versatile intellect, who, not content with an equivocal success in his own sphere of activity, plunges into scientific questions with which he has no real acquaintance, only to obscure them by an aimless rhetoric, and distract the attention of his hearers from the real point at issue by eloquent digressions, and skilled appeals to religious prejudice."

An eye-witness has told the present writer that Huxley's speech produced little effect at the time. In the minds of those of the audience best qualified to weigh biological arguments, there was little doubt but that he had refuted Owen, and simply dispelled the vaporous effusions of the Bishop; but the majority of the audience retained the old convictions. The combat was removed to a wider tribunal. From that time forwards Huxley, by a series of essays, addresses, and investigations, continued almost to the end of his life, tried to convince, and succeeded in convincing, the intellectual world. At the risk of wearying by repetition I shall again insist upon the side of Darwinism that Huxley fought for and triumphed for.

Long before the time of Darwin and Huxley, almost at the beginning of recorded thought, philosophers busied themselves with the wonderful diversity of the living world and with speculations

as to how it had assumed its present form. From the earliest times to this century, theories as to the living world fell into one or other of two main groups. The keynote of one group was the fixity of species : the belief that from their first appearance species were separate, independent entities, one never springing from another, new species never arising by the modification in different directions of descendants of already existing species. The keynote of the other group of theories was the idea of progressive change : that animals and plants as they passed along the stream of time were continually being moulded by the forces surrounding them, and that the farther back the mind could go in imagination the fewer and simpler species would be; until, in the first beginning, all the existing diverse kinds of living creatures would converge to a single point. It may be that, on the whole, the idea of fixity prevailed more among thinkers with a religious bias; but for the most part the theories were debated independently of the tenets of any faith, Christian or other. There were sceptical defenders of fixity and religious upholders of evolution. However, in Christian countries, from the time of the Reformation onwards, a change in this neutrality of religion to theories of the living world took place. As Pascal prophesied, Protestanism rejected the idea of an infallible Church in favour of the idea of an infallible book, and, because it happened that this book included an early legend of the origin of the world in a form apparently incompatible with evolution, Protestantism and, at first, to a lesser and secondary extent, Catholicism, assumed the position that there was no place for evolution in a Christian philosophy. At the end of the eighteenth century, and up to the middle of the nineteenth, the problem was not raised in any acute form. The chief anatomists and botanists were occupied with the investigation and discovery of facts, and, without taking any particular trouble about it, accepted more or less loosely the idea that species were fixed. Now and then an evolutionist propounded his views; but, as a rule, he supported

them with a knowledge of facts very much inferior to that possessed by the more orthodox school. Then came Herbert Spencer, reasserting evolution in the old broad spirit, not merely in its application to species, but as the guiding principle of the whole universe from the integrations of nebulæ into systems of suns and planets to the transformations of chemical bodies. Before his marvellous generalisations had time to grip biologists, there came Darwin; and Darwin brought two things: first, a re-statement of the fact of evolution as applied to the living world, supported by an enormous body of evidence, new and old, presented with incomparably greater force, clearness, patience, and knowledge than had ever been seen before; and, second, the exposition of the principle of natural selection as a mechanism which might have caused, and probably did cause, evolution.

Huxley, as has been shewn, like many other anatomists, was ready for the general principle of evolution. In fact, so far as it concerned the great independent types which he believed to exist among animals, he was more than prepared for it. Let us take a single definite example of his position. In his work on the Medusæ, he had shewn how a large number of creatures, at first sight diverse, were really modifications of a single great type, and he used language which, now that all zoologists accept evolution in the fullest way, requires no change to be understood:

"What has now been advanced will, perhaps, be deemed evidence sufficient to demonstrate—first, that the organs of these various families are traceable back to the same point in the way of development; or, secondly, when this cannot be done, that they are connected by natural gradations with organs which are so traceable; in which case, according to the principles advanced in 57, the various organs are homologous, and the families have a real affinity to one another and should form one group. . . It appears, then, that these five families are by no means so distinct as has hitherto been supposed, but that they are members of one great group, organised upon

one simple and uniform plan, and, even in their most complex and aberrant forms, reducible to the same type. And I may add, finally, that on this theory it is by no means difficult to account for the remarkable forms presented by the Medusæ in their young state. The Medusæ are the most perfect, the most individualised animals of the series, and it is only in accordance with what very generally obtains in the animal kingdom, if, in their early condition, they approximate towards the simplest forms of the group to which they belong."

Such words, written before 1849, only differ from those that would have been written by a convinced evolutionist by a hair's breadth. But Huxley was not an evolutionist then: it was Darwin's work, containing a new exposition of evolution and the new principle of natural selection, that convinced him, not of natural selection but of evolution. At Oxford, in 1860, it was for evolution, and not for natural selection, that he spoke; and throughout his life afterwards, as he expressed it, it was this "ancient doctrine of evolution, rehabilitated and placed upon a sound scientific foundation, since, and in consequence of, the publication of *The Origin of Species*," that furnished him with the chief inspiration of his work. The clear accuracy of his original judgment upon Darwin's work has been abundantly justified by subsequent history. Since 1859 the case for evolution has become stronger and stronger until it can no longer be regarded as one of two possible hypotheses in the field, but as the only view credible to those who have even a moderate acquaintance with the facts. In 1894, thirty years after the famous meeting at Oxford, the British Association again met in that historic town. The President, Lord Salisbury, a devout churchman and with a notably critical intellect, declared of Darwin:

"He has, as a matter of fact, disposed of the doctrine of the immutability of species. . . . Few now are found to doubt that animals separated by differences far exceeding those that distinguish what we know as species have yet descended from common ancestors."

Huxley, in replying to the address, used the following words :

"As he noted in the Presidential Address to which they had just listened with such well-deserved interest, he found it stated, on what was then and at this time the highest authority for them, that as a matter of fact the doctrine of the immutability of species was disposed of and gone. He found that few were now found to doubt that animals separated by differences far exceeding those which they knew as species were yet descended from a common ancestry. Those were their propositions; those were the fundamental principles of the doctrine of evolution."

On the other hand, Huxley all through his life, while holding that natural selection was by far the most probable hypothesis as to the mode in which evolution had come about, maintained that it was only a hypothesis, and, unlike evolution, not a proved fact. In 1863, in a course of lectures to working men, he declared :

"I really believe that the alternative is either Darwinism or nothing, for I do not know of any rational conception or theory of the organic universe which has any scientific position at all beside Mr. Darwin's. . . . But you must recollect that when I say I think it is either Mr. Darwin's hypothesis or nothing; that either we must take his view, or look upon the whole of organic nature as an enigma, the meaning of which is wholly hidden from us; you must understand that I mean that I accept it provisionally, in exactly the same way as I accept any other hypothesis."

In 1878 he wrote :

"How far natural selection suffices for the production of species remains to be seen. Few can doubt that, if not the whole cause, it is a very important factor in that operation; and that it must play a great part in the sorting out of varieties into those which are transitory and those which are permanent."

The difficulty in accepting natural selection as more than a hypothesis is simply that we have no experimental knowledge of its being able to produce the mutual infertility which is so striking a character of species. This difficulty is, in the first place, the difficulty of proving a negative. It might be

possible to prove that its operation actually does produce species; it will always be impossible to prove that, in the past, natural selection, and no other known or unknown agency or combination of agencies, had a share in the process. All naturalists are now agreed that, as a matter of historical fact, it was the propounding of natural selection by Darwin that led to the acceptance of evolution, to the fact that evolution "takes its place alongside of those accepted truths which must be reckoned with by philosophers of all schools." The difficulty as to natural selection still exists, and there is no better way to express it than in Huxley's words, written in the early sixties:

"But, for all this, our acceptance of the Darwinian hypothesis must be provisional so long as one link in the chain of evidence is wanting; and, so long as all the animals and plants certainly produced by selective breeding from a common stock are fertile with one another, that link will be wanting; for, so long, selective breeding will not be proved to be competent to do all that is required of it to produce natural species. . . . I adopt Mr. Darwin's hypothesis therefore, subject to the production of proof that physiological species may be produced by selective breeding; just as a physical philosopher may accept the undulatory theory of light, subject to the proof of the existence of the hypothetical ether; or as the chemist adopts the atomic theory, subject to the proof of the existence of atoms; and for exactly the same reasons, namely, that it has an immense amount of *prima facie* probability; that it is the only means at present within reach of reducing the chaos of observed facts to order; and, lastly, that it is the most powerful instrument of investigation which has been presented to the naturalists since the invention of the natural system of classification, and the commencement of the systematic study of embryology."—*Man's place in Nature*, p. 149.*

* Further details on the subject of this chapter may be obtained in Clodd's excellent volume, *Pioneers of Evolution*, where an account of the history of the idea of evolution from the earliest times is given; and in Poulton's *Charles Darwin and the Theory of Natural Selection*, where there is a particularly valuable chapter upon Huxley's relation to Darwinism.

CHAPTER VIII

VERTEBRATE ANATOMY

WE have seen that some of the most important of the contributions made by Huxley to zoological knowledge were in the field of the lower animals, especially of those marine forms for the study of which he had so great opportunities on the *Rattlesnake*. Much of his zoological work, however, related to the group of back-boned animals. These, by their natural affinities and anatomical structure, are more closely related to man, and, as Huxley began his scientific work as a medical student, the groundwork of all his knowledge was study of the anatomy and physiology of man. Moreover, throughout the greater part of his working life, he had more to do with the extinct forms of life. The vertebrate animals, from the great facility for preservation which their hard skeleton presents, as well as from the extremely important anatomical characters of the skeleton, bulk more largely in the study of palæontology than does any other group. In each of the great groups of vertebrate animals, in fishes, amphibia, reptiles, birds, and mammals, Huxley did important work. Much of this is embodied in his treatise on *Vertebrate Anatomy*, but to some particular parts of it special attention may now be directed, as much because these serve as excellent examples of his method of work as because of their intrinsic importance.

The skull is the most striking feature in the skeleton of vertebrate animals, and to the theory and structure of the vertebrate skull Huxley paid special attention, and his views and summary of

the views of others form the basis of our modern knowledge. This work was put before the public in the course of a series of lectures on Comparative Anatomy given in 1863, while Huxley was Hunterian Professor at the Royal College of Surgeons, and the beginnings of it were contained in a Croonian lecture to the Royal Society in 1858.

The theory of the skull which held the field was known as the vertebral theory. The great bulk of the nervous system of vertebrate animals consists of a mass of tissue lying along the dorsal line of the body and enclosed in a cartilaginous or bony sheath. The nerve tissue is the brain and spinal cord; the sheath is the skull in front and the vertebral column along the greater part of the length of the animal. The brain may be taken simply as an anterior portion of the nerve mass, corresponding in a general way with an expansion of the spinal cord in the region of the anterior limbs and an expansion in the region of the hind limbs, the latter indeed in some extinct creatures surpassing the brain in size. In a similar simple fashion the skull may be taken as an expanded anterior part of the vertebral column, serving as a box for the brain, just as in the regions of the pectoral and pelvic expansions of the cord there are similar expansions of the surrounding bony case. We know now, from greater knowledge of its embryological development, that the brain contains structures peculiar to itself, and differs from the spinal cord in kind as well as in size; but, at the same time, when the vertebral theory of the skull was inaugurated, embryological knowledge and the importance of its relation to anatomical structure were less considered. What Huxley did was to shew that the skull, in its mode of origin and real nature, was not merely an expanded portion of the vertebral column, but that it differed from it in kind.

The hypothesis of the vertebral structure of the skull was due both to Goethe, the great German poet, and Oken, an able but mystic German anatomist. An attempt had been made by Owen to cast

on Goethe the stigma of having tried to rob Oken of the credit for this theory. Huxley set that matter finally at rest, disproving and repelling with indignation the unworthy suggestion. Oken gave out his theory in 1807, and described how it had been first suggested to his mind by the accident of picking up a dried and battered sheep's skull, in which the apparent vertebral structure was very obvious, as, indeed, anyone may see at a glance. It was in 1820, long after the theory had been made current, that the poet first publicly narrated that in a similar way he had long before come to the same conclusion; but Huxley was able to shew that, although announcing it later, Goethe had in reality anticipated the anatomist. A passage occurs in a letter to a friend, of a date in 1790, which admits of no doubt. "By the oddest happy chance, my servant picked up a bit of an animal's skull in the Jews' cemetery at Venice, and, by way of a joke, held it out to me as if he were offering to me a Jew's skull. I have made a great step in the formation of animals." It is an interesting trait in Huxley's character, to find him zealous in defence of the reputation of a great man, even although that man had been dead more than half a century; but it may be added that his just zeal was at least stimulated by the fact that the maligner of Goethe was Owen, the conduct of whom, with regard to Darwin and Huxley, Huxley had had just reason for resenting.

The theory, then, which had dropped stillborn from Goethe, but which Oken developed, was simply that the skull consisted of a series of expanded vertebræ. Each vertebra consists of a basal piece or centrum, the anterior and posterior faces of which are closely applied to the face of an adjoining vertebra, and of a bony arch or ring which encloses and protects the nervous cord. Oken supposed that there were four such vertebræ in the skull, the centra being firmly fused and the arches expanded to form the dome of the skull. Quite correctly, he divided the skull into four regions, corresponding to what he called an ear vertebra, at the back,

through which the auditory nerves passed; a jaw vertebra, in the sphenoidal region, through which the nerves to the jaws passed; an eye vertebra in front, pierced by the optic nerves, and again in front a nose vertebra, the existence of which he doubted at first. Quite rightly, he discriminated between the ordinary bones of the skull and the special structures surrounding the inner ear which he declared to be additions derived from another source. So far it cannot be doubted that the vertebral theory made a distinct advance in our knowledge of the skull. It was to a certain extent, however, thrown into disrepute by various fantastic theories with which Oken surrounded it. Later on, Cuvier lopped these wilder excrescences, and amplified the basis of observation upon which the underlying theory of the unity of type of the skull throughout the vertebrates was based. Cuvier, however, came to reject the theory, except so far as it applied to the posterior or occipital segment of the skull. Later on, Owen resuscitated the theory, first throwing doubt on the merit of Goethe, and then suggesting that Oken, instead of relying on the observed facts, had deduced the whole theory from his own imagination. Owen, although he made no new contribution to fact or theory in this matter, practically claimed the whole credit of it as a scientific hypothesis.

When Huxley took up the subject, the position was that the vertebral theory was in full possession of the field, under the auspices of Owen. Huxley began afresh from observed facts. The first object of his investigation was to settle once for all the question as to whether the skulls of all vertebrates were essentially modifications of the same type. He took in succession the skulls of man, sheep, bird, turtle, and carp, and shewed that in all these there were to be distinguished the same four basi-cranial regions: the basi-occipital, basi-sphenoid, pre-sphenoid, and ethmoid. These were essentially identical with the centra of the four vertebræ of Oken. Similarly, he shewed the composition of the lateral and dorsal walls, proving the essential

identity of the structures involved and of their relations to the nerve exits in the great types he had chosen. In the series of lectures delivered before the College of Surgeons, he extended his observations to a much larger series of vertebrates, and substantially laid down the main lines of our knowledge of the skull. In two important respects his statements were not merely a codification of existing knowledge, but an important extension of it. He distinguished the different modes in which the jaws may be suspended to the skull, and established for these different kinds of suspensoria the names which have ever since been employed. He proved clearly what had been suggested by Oken, that the region of the ear is a lateral addition to the skull, and he distinguished in it three bones, his names for which have since become the common property of anatomists. Finally, he made it plain beyond any possible doubt that the skulls of all vertebrates were built upon a common plan.

Having established the facts, he proceeded to enquire into the theory. There was now a new method for investigating such problems, the method of embryology, which, practically, had not been available to Oken, and of which neither Cuvier nor Owen had made proper use. By putting together the investigations of a number of embryologists, by adding to these himself, and, lastly, by interpreting the facts which his investigations into comparative anatomy had brought to light, he shewed that the vertebral theory could not be maintained. He shewed, by these methods, that, though both skull and vertebral column are segmented, the one and the other, after an early stage, are fashioned on lines so different as to exclude the possibility of regarding the details of each as mere modifications of a common type. "The spinal column and the skull start from the same primitive condition, whence they immediately begin to diverge." "It may be true to say that there is a primitive identity of structure between the spinal or vertebral column and the skull; but it is no more true that the adult skull is a modified vertebral column than it would

be to affirm that the vertebral column is a modified skull." Taking the embryological facts, he shewed that the skull arose out of elements quite different from those of the vertebral column. The notochord alone is common to both. The skull is built up of longitudinal cartilaginous pieces, now known as the "parachordals" and "trabeculæ," of sense capsules enclosing the nose and ear, and of various roofing bones. In the historical development of the skull three grades become apparent: a primitive stage, as seen in Amphioxus, where there is nothing but a fibrous investment of the nervous structures; a cartilaginous grade, as seen in the skate or shark, where the skull is formed of cartilage, very imperfectly hardened by earthy deposits; a bony stage, seen in most of the higher animals. He shewed that in actual development of the higher animals these historical grades are repeated, the skull being at first a mere membraneous or fibrous investment of the developing nervous masses, then becoming cartilaginous, and, lastly, bony. He made some important prophetic remarks as to the probable importance that future embryological work would give to the distinction between cartilage and membrane bones—a prophecy that has been more than fully realised by the investigations of Hertwig and of others. Our present knowledge of the skull differs from Huxley's conception practically only in a fuller knowledge of details. We know now that throughout the series there is a primitive set of structures common to all animals higher in the scale than Amphioxus, and forming the base and lateral walls of the skull. This is termed the chondrocranium, because it is laid down in cartilage; it is composed of the separate elements which Huxley indicated, and, in different animals, as Huxley suggested, the exact limits of the ossification of the primitive cartilages differ in extent, but occur in homologous situations. This primitive skull is roofed over by a series of membrane bones which have no connection in origin with the other portions of the skull, and so far from being represented in the vertebral column, are the

direct descendants of the bony scales clothing the external skin in cartilaginous fishes. In one respect only was Huxley erroneous. Partly by inadvertence, and partly because the minute details of vertebrate embryology became really familiar to zoologists only after the elaborate work of Balfour of Cambridge, Huxley, in his account of the formation of the first beginnings of the skeleton in the embryo, did not distinguish the walls of the primitive groove, which, in reality, give rise to the nervous structures, and those embryonic tissues which form the skeletal system.

The next great piece of work which we may take as typical of Huxley's contributions to vertebrate anatomy, is his classical study on the classification of birds. The great group of birds contains a larger number of species than is known in any other group of vertebrates, and, in this vast assemblage of forms there is strikingly little anatomical difference. The ostrich and the humming-bird might perhaps be taken as types of the extremest differences to be found, and yet, although these differ in size, plumage, adaptations, habits, mode of life, and almost everything that can separate living things, the two conform so closely to the common type of bird-structure that knowledge of the anatomy of one would be a sufficient guide, down to minute details, for dissection of the other. None the less, there are hundreds of thousands of species of birds between these two types. It is not surprising that to reduce this vast assemblage of similar creatures to an ordered system of classification has proved one of the most difficult tasks attempted by zoologists. Before Huxley, it had been attempted by a number of distinguished zoologists; but, for the most part, these had relied too much on merely external characters and on superficial modifications in obvious relation to habits. When Huxley, in the course of a set of lectures on Comparative Anatomy, was about to approach the subject of birds he was asked by Dr. P. L. Sclater how he proposed to treat them. "I intend," he replied, "to treat them as extinct

animals." By that he meant that it was his purpose to make a prolonged study of their skeletal structures the basis of his grouping, following the lines which Cuvier, Owen, and he himself had pursued so successfully in the case of the fossil remains of vertebrates. The result was that this first systematic study of even one set of the anatomical characters of the group completely reformed the method by which all subsequent workers have tried to grapple with the problem; ornithology was raised from a process akin to stamp-collecting to a reasoned scientific study. The immediate practical results were equally important. He was able to shew that among the innumerable known forms there were three grades of structure. The lowest had already been recognised and named by Haeckel; it consisted of the Saururæ, or reptile-like birds, and contained a single fossil form, Archæopteryx, distinguished from all living birds by the presence of a hand-like wing in which the metacarpal bones were well developed and freely movable, and by the possession of a long lizard-like tail actually exceeding in length the remainder of the spinal column. The next group of Ratites, although it contained only the Ostrich, Rhea, Emu, Cassowary, and Apteryx, he shewed to be equivalent in anatomical coherence to the third great group of Carinates, which includes the vast majority of living birds. In his arrangement of the latter group, he laid most stress on the characters of the bony structures which form the palate, and by this simple means was able to lay down clearly at least the main lines of a natural classification of the group.

Huxley's work upon birds, like his work in many other branches of anatomy, has been so overlaid by the investigations of subsequent zoologists that it is easy to overlook its importance. His employment of the skeleton as the basis of classification was succeeded by the work of others who made a similar use of the muscular anatomy, of the intestinal canal, of the windpipe, of the tendons of the feet, and many other structures which display anatomi-

cal modifications in different birds. The modern student finds that all these new sets of facts are much greater in bulk than the work of Huxley, and it is easy for him to remain in ignorance that they were all suggested and inspired by the method which Huxley employed. He finds that further research has supplanted some of Huxley's conclusions, and it is easy for him to remain in ignorance that the conclusions themselves suggested the investigations which have modified them. Huxley's anatomical work was essentially living and stimulating, and often it has become lost to sight simply because of the vast super-structures of new facts to which it gave rise.

Closely associated with vertebrate anatomy is the subject of geographical distribution. In 1857 the study of this important department of zoology was placed on a scientific basis, practically for the first time, by a memoir on the geographical distribution of birds published in the *Journal* of the Linnæan Society of London. It was known in a general way that different kinds of creatures were found in different parts of the world, but little attempt had been made to map out the world into regions characterised by their animal and vegetable inhabitants, as the political divisions of the world are characterised by their different governments and policies. Mr. P. L. Sclater, who two years later became secretary of the Zoological Society of London, in his memoir introduced the subject in the following words :

"It is a well-known and universally acknowledged fact that we can choose two portions of the globe of which the respective fauna and flora shall be so different that we should not be far wrong in supposing them to have been the result of distinct creations. Assuming, then, that there are, or may be, more areas of creation than one. the question naturally arises how many of them are there, and what are their respective extents and boundaries; or, in other words, what are the most natural primary ontological divisions of the earth's surface?"

Sclater's answer was that there are six great regions: Neotropical, Nearctic, Palæarctic, Ethiopian, Indian, and Australian, and his answer, with minor alterations and the addition of a great wealth of detail, has been accepted by zoology.

Two years later, however, Darwin gave a new meaning and importance to Sclater's work, by the new interpretation that his theory gave to the words "centres of creation." Sclater's facts and areas remained the same; Darwin rejected the idea of separate creations in the older sense of the words, and laid stress on the impossibility of accounting for the resemblances within a region and for the differences between regions by climatic differences and so forth. He raised the questions of modes of dispersal and of barriers to dispersal, of similarities due to common descent, and of the modifying results produced by isolation. He gave, in fact, a theory of the "creations" which Sclater had shewn to be a probable assumption. It was in the nature of things that Huxley should make a contribution to a set of problems so novel and of so much importance to zoology. In 1868, in the course of a memoir on the anatomy of the gallinaceous birds and their allies, he made a useful attempt, nearly the first of its kind, to correlate anatomical facts with geographical distribution. Having shewn the diverging lines of anatomical structure that existed in the group of creatures he had been considering, he went on to shew that there was a definite relation between the varieties of structure and the different positions on the surface of the globe occupied at the present time by the creatures in question. He made, in fact, the geographical position a necessary part of the whole idea of a species or of a group, and so introduced a conception which has become a permanent part of zoological science.

With regard to the number and limits of the zoological regions into which the world may be divided, Huxley raised a number of problems which have not yet reached a full solution. Sclater had divided the world into six great regions: the

Nearctic, including the continent of North America, with an overlap into what is called South America by geographers; the Palæarctic, comprising Europe and the greater part of Asia; the Oriental, containing certain southern portions of Asia, such as India south of the Himalayas and many of the adjacent islands; the Ethiopian, including Africa, except north of the Sahara, and Madagascar; the Australian, containing Australia and New Zealand and some of the more south-eastern of the islands of Malay; the Neotropical, including South America. Huxley first called attention to certain noteworthy resemblances between the Neotropical and the Australian regions of Sclater, and held that a primary division of the world was into *Arctogœa*, comprising the great land masses of the Northern Hemisphere with a part of their extension across the equator, and *Notogœa*, which contained Australia but not New Zealand and South America. Although this acute suggestion has not been generally accepted as a modification of Sclater's scheme, it called attention in a striking fashion to some very remarkable features in the distribution of animals. Subsequent writers have considerably extended Huxley's conception of the similarities to be found among the more southern land areas. They have pointed out that the most striking idea of the distribution of land and water on the surface of the globe is to be got by considering the globe alternately from one pole and from the other. In the south, a clump of ice-bound land, well within the Antarctic Circle, surrounds the pole. All else is a wide domain of ocean broken only where tapering and isolated tongues of land, South America, the Cape, Australia, lean down from the great land masses of the north. On the other hand, all the great land masses expand in the Northern Hemisphere, and shoulder one another round the North Pole. America is separated from Asia only by the shallowest and narrowest of straits; an elevation of a few fathoms would unite Greenland with Europe. Science points definitely to some part of the great northern land area as the

place of origin for at least the larger terrestrial forms of life. We know that these arose successively, primitive birds like the ostriches being older than higher forms like the parrots and singing birds; the pouched marsupials preceding the antelopes and the lion; the lemurs coming before the man-like apes. Each wave of life spread over the whole area, reproducing after its kind; then, pressing round the northern land area, it met a thousand different conditions of environment, different foods, enemies, and climates, and broke up into different genera and species. But there was never a wave of life that was not followed by another wave. In the struggle for existence between the newer and the older forms, the older forms were gradually driven southwards towards the diverging fringes of the land masses. The vanquished left behind them on the field of battle only their bones, some of which became fossils. Sometimes succeeding waves swept along to the extreme limits of the land, and many early types were utterly destroyed. But others found sanctuary in the ends of the South, and such survivors of older and earlier types of life cause a similarity between the southern lands that Huxley called Notogœa, although the extent of his region must be increased.

Recently, however, there has been a recurrence to Huxley's suggested union of South America and Australia, based on new evidence of a direct kind, quite different from that which had just been given. Various groups of naturalists have stated that there are similarities between the invertebrate inhabitants of Australia and of South America of a kind which makes the existence of a direct land connection in the Southern Hemisphere extremely probable. Moreover, Ameghino has described some marsupial fossils from South America which, he states, belong to the Australian group of Dasyuridæ, and Oldfield Thomas has recorded a mammal from South America which is unlike the opossums of America but like the diprotodonts of Australia. So that, while the general opinion has been against Huxley's division, Notogœa, in the strict meaning

which he gave to it, there has recently been an opinion growing in its favour.

Huxley also made minor alterations in Sclater's scheme by forming an additional circumpolar region for the Northern Hemisphere, and by elevating New Zealand into a separate region, distinct from Australia. On these points there is a balance of opinion against his views.

Before leaving the subject of Huxley's contributions to vertebrate anatomy, the actual details of which would occupy far too much space, it is necessary to mention the great importance to zoology of the new terms and new ideas he introduced into classification. His mind was, above all things, orderly and comprehensive, and while, in innumerable minute points, from the structure of the palate of birds to the structure of the roots of human hair (actually the subject of Huxley's first published contribution to scientific knowledge), he added to the number of known facts, he did even more important work in co-ordinating and grouping together the known body of facts. To him are due not only the names, but the idea, that mammalian animals fall into three grades of ascending complexity of organisation: the reptile-like Prototheria, which lay large eggs, and which have many other reptilian characters; the Metatheria, or marsupial animals; the Eutheria, or higher animals, which include all the common animals from the mole or rabbit up to man. In a similar fashion, he grouped the vertebrates into three divisions and named them: Ichthyopsida, which include the fish and Amphibia, creatures in which the aquatic habit dominates the life history and the anatomical structure; Sauropsida, including birds and reptiles, on the close connection between which he threw so much light; Mammalia, distinguished by their habit of suckling the young.

CHAPTER IX

MAN AND THE APES

EVEN before the publication of *The Origin of Species* there was a considerable nervousness in the minds of the more orthodox as to discussions on the position of the human species in zoological classification. Men of the broadest minds, such as Lyell, who himself had suffered considerably from outside interference with the right to publish scientific conclusions, were strongly opposed to anything that seemed to tend towards breaking down the barrier between man and the lower creatures. Sir William Lawrence, a very distinguished and able man, had been criticised with the greatest severity, and had been nearly ostracised, for a very mild little book *On Man;* and Huxley tells us that the electors to the Chair of a Scotch University had refused to invite a distinguished man, to whom the post would have been acceptable, because he had advocated the view that there were several species of man. The court, political leaders, and society generally, resented strongly anything that seemed at all likely to disturb the somewhat narrow orthodoxy prevalent in those times; and, as there were comparatively few posts open to scientific men, and comparatively greater chances of posts being made for men of talent and ability who adhered to the respectable traditions, those who tampered with so serious a question as the place of man were likely to burn their fingers severely. However, the difficulties of discussing these problems were much greater immediately after 1859. One of the most surprising things in the history of last

century is the sudden intensity of the opposition of the public, particularly the respectable and religious public, to zoological writing upon man, immediately after the publication of the *Origin*. Before that time anatomists did not necessarily hesitate to point out the close resemblance between the anatomy of man and that of the higher apes, and the difficulties anatomists had in making anatomical distinctions of value between them. Thus Owen, who, as a writer, was rather unusually nervous about expressing facts to which any objection might be raised by those outside the scientific world, had written the following paragraph in the course of an essay on the characters of the class Mammalia, published, in 1857, in the *Journal of the Proceedings of the Linnæan Society:*

"Not being able to appreciate or conceive of the distinction between the psychical phenomena of a chimpanzee and of a Boschisman or of an Aztec, with arrested brain-growth, as being of a nature so essential as to preclude a comparison between them, or as being other than a difference of degree, I cannot shut my eyes to the significance of that all-pervading similitude of structure—every tooth, every bone, strictly homologous—which makes the determination of the difference between *Homo* and *Pithecus* the anatomist's difficulty."

It is true, he went on to explain his belief in the existence of certain characters in the brain which seemed to him to justify the separation of man in a different group from that in which the apes were placed; but it is certain that he regretted having said anything which seemed to support the Darwinian view; and, two years later, when the opposition to Darwin was in its acutest stage, Owen withdrew his words. His "Reade Lecture," delivered in the University of Cambridge, was in all respects a reprint of the essay from which we have just quoted, but the apparently dangerous words were omitted. More than that, the points insisted on in the essay as being sufficient for the purpose of separating man in zoological classification were

elevated into a reason against descent. Although Huxley, in several addresses and publications, disproved the existence of the alleged differences, and although Sir William Flower gave an actual demonstration shewing the essential identity of the brain of man and of the apes in the matter in question, Owen never admitted his error.

Since an anatomist so distinguished and acute as Owen allowed his judgment to be completely overborne by the storm of prejudice against Darwinism, it is not surprising that those who were not anatomists should have held up to ridicule all idea of comparison between man and the apes. In *The Origin of Species* itself, no elaborate attempt had been made to set forth the anatomical arguments as to community of descent for man and the apes. But it was made sufficiently plain, and the public laid hold of the point eagerly, that the doctrine of descent was not meant to exclude man from the field of its operation. Huxley, in the course of his ordinary work as Professor of Biology, had naturally turned his attention to the anatomy and classification of the higher animals. When Owen's essay appeared, he found that he was unable to agree with many of the conclusions contained in it, and had set about a renewed investigation of the matter. And so when the question became prominent in 1860, Huxley was ready with material contributions to it. He believed, moreover, that, as Darwin was not specially acquainted with the anatomy and development of vertebrates, there was an opportunity for doing a real service to the cause of evolution. Accordingly, in 1860, he took for the subject of a series of lectures to working-men the "Relation of Man to the Lower Animals," and, in 1862, expanded the lectures into a volume called *Man's Place in Nature*. When it was ready, he was prepared to say with a good conscience that his conclusions "had not been formed hastily or enunciated crudely."

"I thought," he wrote in the preface to the 1894 edition, "I had earned the right to publish them, and

even fancied I might be thanked, rather than reproved, for so doing. However, in my anxiety to promulgate nothing erroneous, I asked a highly competent anatomist and very good friend of mine to look through my proofs, and, if he could, point out any errors of fact. I was well pleased when he returned them without any criticism on that score; but my satisfaction was speedily dashed by the very earnest warning, as to the consequences of publication, which my friend's interest in my welfare led him to give; but, as I have confessed elsewhere, when I was a young man there was just a little—a mere *soupçon*—in my composition of that tenacity of purpose which has another name, and I felt sure that all the evil things prophesied would not be so painful to me as the giving up of that which I had resolved to do, upon grounds which I conceived to be right. So the book came out, and I must do my friend the justice to say that his forecast was completely justified. The Boreas of criticism blew his hardest blasts of misrepresentation and ridicule for some years; and I was even as one of the wicked. Indeed, it surprises me, at times, to think how anyone who had sunk so low could have emerged into, at any rate, relative respectability."

Further, in the same preface, Huxley strongly advises others to imitate his action in this matter. There are now, and no doubt there always will be, truths "plainly obvious and generally denied." Whoever attacks the current ideas is certain, unless human nature changes greatly, to encounter a bitter opposition, and there will always be those among his friends who recommend him to temper truth by prudence. Huxley's advice is different:

"If there is a young man of the present generation who has taken as much trouble as I did to assure himself that they are truths, let him come out with them, without troubling his head about the barking of the dogs of St. Ernulphus. *Veritas prævalebit*—some day; and, even if she does not prevail in his time, he himself will be all the better and wiser for having tried to help her. And let him recollect that such great reward is full payment for all his labour and pains."

Although they were written so long ago, the lectures on "Man's Place in Nature" are still a

valuable treatise on the subject, and we shall give an outline of them, mentioning the chief points in which further work has been done. Information concerning the man-like apes was scattered in very different places, in the grave records of scientific societies, in the letters of travellers and missionaries, in the reports of the zoological societies which had been in possession of living specimens. The facts had to be sifted out from a great mass of verbiage and unfounded statement. With a characteristic desire for historical accuracy, more usual in a man of letters than in an anatomist, Huxley began with a study of classical and mediæval legends of the existence of pigmies and man-like creatures; but, while recognising that legends of satyrs and fauns were presages of the discovery of man-like apes, he was unable to find any actual record earlier than that contained in Pigafetta's *Description of the Kingdom of Congo*, drawn up from the notes of a Portuguese sailor and published in 1598. The descriptions and figures in this work apparently referred to chimpanzees. From this date onwards he traces the literature of the animals in question, and then proceeds to give an account of them.

There are four distinct kinds of man-like apes: in Eastern Asia the Orangs and the Gibbons; in tropical Africa, the Chimpanzees and the Gorillas. All these have certain characters in common. They are inhabitants of the old world; they all have the same number of teeth as man, possessing four incisors, two canines, four premolars, and six true molars in each jaw, in the adult condition, while the milk dentition, as in man, consists of twenty teeth—four incisors, two canines, and four molars in each jaw. Since Huxley wrote, a large bulk of additional work upon teeth has been published, and we now know that man and the anthropoid apes display the same kind of degenerative specialisation in their jaws. Simpler and older forms of mammals had a much larger number of teeth, and these differed among themselves more than the teeth of the higher forms. In the Anthro-

poids and Man, the jaws are proportionately shorter and less heavy than in simpler forms, and, in correspondence with this, the number of the teeth has become reduced, while the teeth themselves tend to form a more even row. The canine or eye-teeth are relatively smaller in the gorilla than in primitive mammals; they are still smaller in the lower races of man; while in ordinary civilised man they do not project above the others. The shortening of the jaw is still proceeding, and, although in lower races of man the last molar or wisdom tooth is almost as large as the molars in front of it, in the higher races the wisdom tooth is much smaller and frequently does not develop at all, or begins to decay very soon after its appearance. If the process of extinction of lower races were to proceed much further, so that civilised white races became the only human inhabitants of the earth, then the gap between the Anthropoids and Man would be wider than it now is; man would be characterised by the presence of one tooth less than the anthropoids, just as the anthropoids and some lower monkeys are characterised by having one tooth less than monkeys still lower.

In all, the nostrils have a narrow partition and look downwards as in man. The arms are always longer than the legs, the difference being greatest in the orang and least in the chimpanzee. We know now that in the lower races of man, the arms are proportionately longer than in higher races, and it has been shewn that, although there is a general proportion between the length of the long bones and the height of the whole body in man, so that the height may be calculated with an average error from these bones, yet the probable error is greater when the calculation is made from the arms than when it is made from the legs. In fact, the length of arm as compared to the length of leg and to whole height is a more variable feature in man than the length of leg.

In all the anthropoids, the forelimbs end in hands with longer or shorter thumbs, and the great toe, always smaller than in man, is far more movable

and can be opposed like a thumb to the other toes. Since Huxley wrote, a considerable amount of evidence has been collected shewing that partial opposability of the toe in man is not uncommon, and that there is evidence as to a tendency to increase of length of the great toe within historical times. None of the great apes have tails, and none of them have the cheek pouches common among lower monkeys.

Huxley then gives an account of the natural history of these animals, an account which still remains the best in literature. He sums up the habits of the Asiatic forms as follows:

1. They may readily move along the ground in the erect, or semi-erect position, and without direct support from the arms.

2. They may possess an extremely loud voice, so loud as to be readily heard one or two miles.

3. They may be capable of great viciousness and violence when irritated; and this is especially true of adult males.

4. They may build a nest to sleep in.

He finds the same general characters in the case of the gorilla and chimpanzee, but in their case there was not then quite so reliable evidence upon which to go.

Although, since Huxley wrote, there has been much greater opportunity of studying anthropoid apes, both in confinement and in their native haunts, there is not much to add to his account. Some little time ago, the world was interested by the assertion of a clever American that he had discovered a kind of language used by the higher apes, and that he was able to communicate with them. Mr. Garnier, the person in question, declared his intention of going out to tropical Africa and establishing himself in a strong cage in the forests inhabited by gorillas and chimpanzees, in the hope that, impelled by curiosity, they would look upon him as we look on monkeys in a zoological garden, and that he would thus be able to make his knowledge and records of monkey language more perfect. As a matter of

fact he went to Africa, and on his return published a volume which aroused the indignation of naturalists. There was internal evidence that he had gone no further than the garden of a coast station, and his pretended account of the habits of monkeys as they lived in their native haunts contained nothing that was not already known. There is no doubt but that the anthropoid apes, like many other animals, use modulations of their voice to express emotional states; that, in fact, they have love-cries and cries of warning, of alarm, and of pleasure; but there is not the smallest evidence to suppose that in the case of the anthropoids these cries approach more nearly to speech than the cries of any other of the higher mammals.

Since Huxley's volume was published, a large amount of information has been published by Darwin, Romanes, and others upon the mental capacities of anthropoids kept in confinement, and the result of this has been to prove that the anthropoids, in especial the chimpanzees, possess mental powers more akin to those of man than are to be found in the most intelligent of the quadrupeds. We may cite some instances of these higher powers. Vosmaern had a tame female orang-outan that was able to untie the most intricate knot with fingers or teeth, and took such pleasure in doing it that she regularly untied the shoes of those who came near her. The female chimpanzee called Sally, that lived for many years in the Zoological Society's Gardens in London, was taught by its keeper and by Romanes an interesting variety of "tricks" involving at least the rudiments of what may be called human intelligence. Among other feats, it would pick up from the floor and present to the keeper or to a visitor, a stated number of straws up to five. Many monkeys seem nearly purely destructive in their dealings with objects within their reach; but Leutemann tells of an orang-outan which "tried to put to its proper use whatever was given to him. To my great surprise he attempted to put on a

pair of gloves. He supported himself on a light walking-cane and, when it bent under him, made ridiculous motions to right it again." Brehm tells of a chimpanzee:

"After eating, he at once begins to clean up. He holds a stick of wood in front of him, or puts his hands in his master's slippers, and slides about the room, then takes a cloth and scrubs the floor. Scouring, sweeping, and dusting are his favourite occupations; and, when he once gets hold of the cloth, he never wants to give it up."

Falkenstein has given a detailed description of a gorilla which was remarkable for his delicacy in eating.

"He would take a cup or glass with the greatest care, using both hands to carry it to his mouth, and setting it down so carefully that I do not remember having lost a single piece of crockery through him, though we had never tried to teach him the use of such vessels, wishing to bring him to Europe as nearly in his natural condition as possible."

These and a multitude of similar observations which have been made since Huxley wrote are typical of the increase of our knowledge on the habits and capacities of the anthropoid apes. They all serve to shew that apes possess an instinct for experimental investigation of everything with which they are surrounded, and that their imitative faculties are peculiarly great. The importance of this, from the point of view of Huxley's argument, is great. The difference between the instincts of the lower animals and the intelligence of man is that instincts are to a large extent fixed and mechanical. The proper performance of an instinct demands the presence of exactly the right external conditions for its accomplishment. In the absence of these conditions, the call to perform the instinctive action is equally great, and results in useless performances. In many of the higher animals these elaborate instincts are more general in their character, and are supplemented by a

considerable but varying aptitude for modification of instinctive action to suit varieties of surrounding circumstances. As this intelligence becomes more and more developed, the blind, mechanical instinct becomes weaker. A large number of instances might be given of such instincts modified by dawning intelligence. The chief factors in producing the change are, as has been shewn by Professor Groos, the possession of a general instinct to imitate and to experiment, and the existence of a period of youth in which the young creature may practise these instincts, and so prepare itself for the more serious purposes of adult life. The anthropoid apes seem to possess these experimental instincts to an extent much greater than that observed in any other class of animals, and, as they have a long period of youth, they have the opportunity of putting them into practice to the fullest possible extent.

From the natural history of the anthropoid apes, Huxley passed to consideration of their relation to man, prefacing his observations with a passage defending the utility of the enquiry, a passage necessary enough in those days of prejudice, but now chiefly historical interest:

"It will be admitted that some knowledge of man's position in the animate world is an indispensable preliminary to the proper understanding of his relations to the universe; and this again resolves itself in the long run into an enquiry into the nature and the closeness of the ties which connect him with those singular creatures whose history has been sketched in the preceding pages.

"The importance of such an enquiry is, indeed, intuitively manifest. Brought face to face with these blurred copies of himself, the least thoughtful of men is conscious of a certain shock; due perhaps not so much to disgust at the aspect of what looks like an insulting caricature, as to the awakening of a sudden and profound mistrust of time-honoured theories and strongly rooted prejudices regarding his own position in nature, and his relations to the underworld of life; while that which remains a dim suspicion for the unthinking, becomes a vast argument, fraught with the deepest consequences, for all who are acquainted

with recent progress of the anatomical and physiological sciences."

Huxley then proceeded to elaborate the argument from development for the essential identity of man and the apes. The adult forms of animals are much more complex than their embryonic stages, and the series of changes passed through in attaining the adult condition make up the embryological history of the animal. Huxley took the embryology of the dog as an example of the process in the higher animals generally, and as it had been worked out in detail by a set of investigators. The dog, like all vertebrate animals, begins its existence as an egg; and this body is just as much an egg as that of a fowl, although, in the case of the dog, there is not the accumulation of nutritive material which bloats the egg of the hen into its enormous size. Since Huxley wrote, it has been shewn that among the mammalian animals there has been a gradual reduction in the size of the egg. The ancestors of the mammals laid large eggs, like those of birds or reptiles; and there still exist two strange mammalian creatures, the Ornithorhynchus and Echidna of Australia, which produce large, reptilian-like eggs. The ancestors of most living mammalia acquired the habit of retaining the eggs within the body until they were hatched; and as a result of this, certain structures which grow out from the embryo while it is still within the egg and become applied to the inner wall of the porous shell for the purpose of obtaining air, got their supply of oxygen, not from the outer air, but from the blood-vessels of the maternal tissues. When this connection (called the placenta) between embryo and mother through the egg-shell became more perfect, not only oxygen but food-material was obtained from the blood-vessels of the mother; and, in consequence, it became unnecessary for the eggs to be provided with a large supply of food-yolk. Among existing marsupial animals, which, on the whole, represent a lower type of mammalian structure

than ordinary mammals, there is more food-yolk than in ordinary mammals, and less food-yolk than in the two egg-laying mammals. In the ordinary mammals, such as the rabbit, dog, monkey, and man, there is practically no yolk whatever deposited in the egg; the egg is of minute size, and the embryo obtains most of its food from the maternal blood.

The small egg of the mammal divides into a number of cells, which form a hollow sphere; on the upper surface of this the development of organs begins with the formation of a depression which indicates the future middle line of the animal, and is, in fact, the beginning of the nervous system. Under this is formed a straight rod of gelatinous material, the foundation of the vertebral column, and the body of the embryo is gradually pinched off from the surface of the hollow sphere. After tracing the details of this process, Huxley proceeded as follows :

"The history of the development of any other vertebrate animal, lizard, snake, frog or fish, tells the same story. There is always, to begin with, an egg, having the same essential structure as that of the dog; the yolk of that egg always undergoes division, or segmentation, as it is often called; the ultimate products of that segmentation constitute the building materials for the body of the young animal; and this is built up round a primitive groove, in the floor of which a notochord is developed. Furthermore, there is a period in which the young of all these animals resemble one another, not merely in outward form, but in all essentials of structure, so closely, that the differences between them are inconsiderable, while in their subsequent course they diverge more and more widely from one another. And it is a general law, that, the more closely any animals resemble one another in adult structure, the longer and the more intimately do their embryos resemble one another; so that, for example, the embryos of a snake and of a lizard remain like one another longer than do those of a snake and of a bird; and the embryos of a dog and of a cat remain like one another for a far longer period than do those of a dog and a bird; or of a dog and an opossum; or even than those of a dog and a monkey."

This general rule, that the longer the paths of embryonic development of two animals keep identical the more nearly the two animals are related, when Huxley wrote, was founded on a much smaller number of facts than are now known. Since 1860 an enormous bulk of embryological investigation has been published, and the total result has been to confirm Huxley's position in the fullest possible way. A certain number of exceptions have been found, but these exceptions are so obviously special adaptations to special circumstances that their existence only makes the general truth of the proposition more clear. The most common kind of exception occurs when two closely related animals live under very different conditions. For instance, many marine animals have close allies that in comparatively recent times have taken to live in fresh water. The conditions of life in fresh water are very different, especially for delicate creatures susceptible to rapid changes of temperature, or unable to withstand strong currents. Thus most of the allies of the fresh-water crayfish, which live in the sea, lay eggs from which there are soon hatched minute, almost transparent larvæ, exceedingly unlike the adult. In the comparatively equable temperature of sea-water, and in the usual absence of strong currents, these small larvæ, as Huxley shewed later in his volume on the *Crayfish*, live a free life, obtaining their own food, and by a series of slow transformations gradually acquire the adult form. In fresh water, however, the delicate larvæ would be unable to live, and the mode of development is different. The series of slow transformations is condensed, and takes place almost entirely inside the egg-shell; so that, when hatching occurs, the young crayfish is exceedingly like the adult. Apart from such special cases, it is true that the study of development affords a clear test of closeness of structural affinity.

Huxley then proceeds to discuss the development of man.

"Is he something apart? Does he originate in a totally different way from dog, frog, and fish, thus justifying those who assert him to have no place in nature, and no real affinity with the lower world of animal life? Or does he originate in a similar germ, pass through the same slow and gradually progressive modifications, depend on the same contrivances for protection and nutrition, and finally enter the world by the help of the same mechanism? The reply is not doubtful for a moment, and has not been doubtful any time these thirty years. Without question, the mode of origin, and the early stages of the development of man are identical with those of animals immediately below him in the scale; without doubt, in these respects, he is far nearer the apes than the apes are to the dog."

Then, on lines with which, from continuous repetition and expansion by authors subsequent to him, we have now become familiar, Huxley compared, stage by stage, the development of man with that of other animals, and shewed, first, its essential similarity, and then that in every case where it departed from the development of the dog it resembled more closely the development of the ape. He went on to review the anatomy of man:

"Thus, identical in the physical processes by which he originates—identical, in the early stages of his formation—identical in the mode of his nutrition before and after birth, with the animals which lie immediately below him in the scale—Man, if his adult and perfect structure be compared with theirs, exhibits, as might be expected, a marvellous likeness of organisation. He resembles them as they resemble one another—he differs from them as they differ from one another. And, though these differences cannot be weighed and measured, their value may be readily estimated; the scale or standard of judgment, touching that value, being afforded and expressed by the system of classification of animals now current among zoologists."

Having explained the general system of zoological classification, he tried to dispel preliminary prejudice by inducing his readers or hearers to take an outside view of themselves.

"Let us endeavour for a moment to disconnect our thinking selves from the mask of humanity; let us imagine ourselves scientific Saturnians, if you will, fairly acquainted with such animals as now inhabit the earth, and employed in discussing the relations they bear to a new and singular 'erect and featherless biped,' which some enterprising traveller, overcoming the difficulties of space and gravitation, has brought from that distant planet for our inspection, well preserved, may be, in a cask of rum. We should all, at once, agree upon placing him among the mammalian vertebrates; and his lower jaw, his molars, and his brain, would leave no room for doubting the systematic position of the new genus among those mammals whose young are nourished during gestation by means of a placenta, or what are called the placental mammals.

"Further, the most superficial study would at once convince us that, among the orders of placental mammals, neither the whales, nor the hoofed creatures, nor the sloths and ant-eaters, nor the carnivorous cats, dogs, and bears, still less the rodent rats and rabbits, or the insectivorous moles and hedgehogs, or the bats, could claim our *Homo* as one of themselves.

"There would remain, then, but one order for comparison, that of the apes (using that word in its broadest sense), and the question for discussion would narrow itself to this—Is Man so different from any of these apes that he must form an order by himself? Or does he differ less from them than they differ from one another—and hence must take his place in the same order with them?

"Being happily free from all real or imaginary personal interest in the results of the enquiry thus set afoot, we should proceed to weigh the arguments on one side and on the other, with as much judicial calmness as if the question related to a new opossum. We should endeavour to ascertain, without seeking either to magnify or diminish them, all the characters by which our new mammal differed from the apes; and if we found that these were of less structural value than those which distinguish certain members of the ape order from others universally admitted to be of the same order, we should undoubtedly place the newly discovered tellurian genus with them."

In pursuit of this method, and taking the gorilla as the type for immediate comparison with man,

he passed in review the various anatomical structures, shewing that in every case man did not differ more from the gorilla than the gorilla differed from other great apes. We shall take a few examples of his methods and results, reminding our readers, however, that Huxley carried his comparisons into every important part of the anatomical structure.

There is no part of the skeleton so characteristically human as the bones which form the pelvis, or bony girdle of the hips. The expanded haunch-bones form a basin-like structure which affords support to the soft internal viscera during the habitually upright position, and gives space for the attachment of the very large muscles which help man to assume and support that attitude. In the gorilla this region differs considerably from that in man. The haunch-bones are narrower and much shallower, so that they do not form so convenient a supporting basin; they have much less surface for the attachment of muscles. The gibbon, however, differs more from the gorilla than the latter from man. The haunch-bones are flat and narrow, and totally devoid of any basin-like formation; the passage through the pelvis is long and narrow, and the ischia have outwardly curved prominences, covered in life by callosities on which the animal habitually rests, and forming coarse, corn-like patches of skin wholly absent in the gorilla, in the chimpanzee, in the orang, and in man.

In the characters of the hands, the feet, and the brain, certain real or supposed structural distinctions between man and the apes had been relied upon.

"Man has been defined as the only animal possessed of two hands terminating his fore-limbs, and of two feet terminating his hind-limbs, while it has been said that all the apes possess four hands: and he has been affirmed to differ fundamentally from all the apes in the characters of his brain, which alone, it has been strangely asserted and reasserted, exhibits the structures known to anatomists as the posterior lobe, the

posterior cornu of the lateral ventricle, and the hippocampus minor.

"That the former proposition should have gained general acceptance is not surprising—indeed, at first sight, appearances are much in its favour; but, as for the second, one can only admire the surpassing courage of its enunciator, seeing that it is an innovation which is not only opposed to generally and justly accepted doctrines, but which is directly negatived by the testimony of all original enquirers who have specially investigated the matter; and that it has neither been, nor can be, supported by a single anatomical preparation. It would, in fact, be unworthy of serious refutation except for the general and natural belief that deliberate and reiterated assertions must have some foundation."

The last remarks referred, of course, to the statements of Owen, which had made a great impression at the time and the result of which still lingers in some of the worse-informed treatises attacking evolution. Huxley gave a lucid account of the general structure and arrangement of the brain in the vertebrate series, explaining the well-known fact that from fish up to man the general ground-plan of the brain is identical, but that there is a progressive increase in the complexity and in the size of some parts compared with others. Next, he shewed that, so far from its being possible to erect any barrier in the structure of the brain between man and the apes, there exists among the mammals an almost complete series of gradations from brains a little higher than that of the rabbit to brains a little lower than that of man. He laid great stress on

"the remarkable circumstance that though, so far as our present knowledge extends, there *is* one structural break in the series of forms of simian brains, this hiatus does not lie between man and the man-like apes, but between the lower and the lowest simians; or, in other words, between the old and new-world apes and monkeys, and the lemurs. Every lemur which has yet been examined, in fact, has its cerebellum partially visible from above, and its posterior lobe, with the contained posterior cornu and hippocampus minor,

more or less rudimentary. Every marmoset, American monkey, old-world monkey, baboon, or man-like ape, on the contrary, has its cerebellum entirely hidden, posteriorly, by the cerebral lobes, and possesses a large posterior cornu, with a well-developed hippocampus minor." . . . "So far from the posterior lobe, the posterior cornu, and the hippocampus minor being structures peculiar to, and characteristic of man, as they have over and over again been asserted to be, even after the publication of the clearest demonstration of the reverse, it is precisely these structures which are the most marked cerebral characters common to man with the apes. They are among the most distinctly simian peculiarities which the human organism exhibits." . . . "Man differs from the chimpanzee or the orang, so far as cerebal structure goes, less than these do from the monkeys, and the difference between the brains of the chimpanzee and of man is almost insignificant, when compared with that between the chimpanzee brain and that of a lemur."

Although Huxley found no structural differences between the brains of man and of anthropoid apes, he was careful to lay great stress on the important difference in size and weight. A full-grown gorilla is nearly twice as heavy as a European woman, and yet the heaviest known gorilla brain probably does not exceed twenty ounces in weight, while healthy adult human brains probably never weigh less than thirty-one or thirty-two ounces. This difference is not of systematic importance; for cranial capacities shew that relatively and absolutely there is a greater difference in brain-weight between the lowest and highest human beings than there is between the highest ape and the lowest human being.

In dealing with the suggestion that man differs from the apes in being bimanous, while the apes are quadrumanous, Huxley first explained and discussed what the exact differences between hands and feet are. He shewed that in man the foot is absolutely distinguished from the hand by three structural points, although the two organs are similar in general ground-plan. These structural points are:

1. The arrangement of the tarsal bones.

2. The possession of a shorter flexor and short extensor muscle of the digits.

3. The possession of a muscle named *peronæus longus*.

Then he described the foot of the gorilla, and shewed that although it was superficially hand-like, it possessed all the structural characters that distinguish a foot from a hand. Tracing the structure of the foot downwards through the series of anthropoids and monkeys, he established clearly that, while important differences existed in nearly every single creature, the differences between the gorilla and man were not greater than those between the gorilla and other anthropoids, and less than between the gorilla and lower monkeys.

This wonderful series of lectures ranks very high among the important works of Huxley. It is true that a considerable proportion of the work was not absolutely original, but it had all been specially verified by him. It was a task undertaken with the greatest courage, and with a care equal to the courage; and it settled conclusively for all time the impossibility of making between man and the anthropoids any anatomical barriers greater than those which exist between the different although closely related members of any of the other family groups in the animal kingdom. The advance of knowledge has only added to the details of Huxley's argument; it has not made any reconstruction of it necessary. A writer on the same subject to-day would to all certainty make use of the same general methods. The chief differences, perhaps, that would be made are two: First, greater stress would be laid on the distinction, first made by Huxley himself, between intermediate and linear types. To use the popular phrase, a great deal of water has passed under the bridges since the separation of man from the ape-like progenitors common to him and to the existing anthropoids. It has already been pointed out that the gradual extinction of lower races of man is widening the apparent gap between existing

man and existing apes; and evidence accumulates that many still more primitive and more ape-like races of man than the lowest existing savages have disappeared from the surface of the earth. Moreover, we know that existing anthropoids are the degenerate and scattered remnants of what was once a much more widely spread and more important group. We have some reason for believing the contrary, and no reason for believing that the surviving anthropoids represent the most man-like apes that have lived.

The second great point in which a modern writer would amend Huxley's statement of the case is more purely anatomical. One result of Darwin's work has been that anatomists attend much more closely to the slight variations of anatomical structure to be found among individuals of the same species. A comparison between an individual human body and the body of an individual gorilla is not now considered sufficient. The comparison must be made between the results of dissection of a very large number of men and of a very large number of gorillas. The anatomy of a type is not the anatomy of an individual; it is a kind of central point around which there oscillate the variations presented by the individuals belonging to the type. So far as this newer method has been applied, it has been found that the variations of the gorilla type frequently, in the case of individual organs, overlap the variations of the human type, and that the structure of man differs from the structure of any anthropoid type only in that the abstract central point of its variations is slightly different from the abstract central point of the variations presented by individual orangs, gorillas, and chimpanzees.

CHAPTER X

SCIENCE AS A BRANCH OF EDUCATION

LESS than half a century ago, there was practically no generally diffused knowledge of even the elements of science and practically no provision for teaching it. Medical students, in the course of their professional education, received some small instruction in botany, chemistry, and physiology; in the greater universities of England and the Continent there were not in all a dozen professorships of science apart from special branches of medicine; in the Scottish universities there were one or two dreamy chairs of "Natural and Civil History," the occupiers of which were supposed to dispense instruction in half a dozen sciences. There was no scientific teaching at the public schools; there were practically no books available for beginners in science, and even the idea of guides to laboratory work had not been invented. Huxley, addressing in 1854 a particularly select audience in St. Martin's Hall, London, spoke to them of the

"utter ignorance as to the simplest laws of their own animal life, which prevails among even the most highly educated persons in this country." "I am addressing," he said, "I imagine, an audience of cultivated persons; and yet I dare venture to assert that, with the exception of those of my hearers who may chance to have received a medical education, there is not one who could tell me what is the meaning and use of an act which he performs a score of times every minute, and whose suspension would involve his immediate death:—I mean the act of breathing—or who could state in precise terms why it is that a confined atmosphere is injurious to health."

The power to state the precise meaning of even a common physiological act is probably not yet possessed by all educated people; but no one can doubt that there is now a very generally diffused knowledge of and interest in the ordinary processes of living bodies. It is almost impossible for any of us to escape some amount of natural knowledge at school, at college, from lectures, or from books. Certainly those of us who have a natural inclination towards knowledge of that kind can hardly fail to have the opportunity of acquiring it. Every library abounds in elementary and advanced scientific books; every university and many schools have their lectures and laboratories for science, and there is scientific teaching involved in every educational curriculum. To attempt a complete account of how this radical change in the attitude of the world to science has come about would be to attempt to write the history of European civilisation in the last half-century. A thousand causes have been contributory; but among these causes two have been of extraordinary importance —an idea and a man. The idea is the conception of organic evolution, and the man was Huxley. The idea of evolution clothed the dead bones of anatomy with a fair and living flesh, and the new body left the dusty corners of museums to pervade the world, arousing the attention and interest of all. A large part of the prodigious mental activities of Huxley was devoted to compelling the world to take an interest in biological science. Had his life-work been no more than this side of it, it would have been of commanding importance. A mere enumeration of the modes in which he assisted in arousing attention to science among all classes would fill many pages. Almost before he was settled in London, in the lecture from which we quoted at the beginning of this chapter, he urged the "educational value of the natural history sciences." In 1869 in a speech in Liverpool; in 1870 at University College, London; in 1874 as his Rectorial address in the University of Aberdeen; in 1876 at the opening ceremonial of the Johns

Hopkins University at Baltimore; in the same year at South Kensington; in 1877 in a separate essay; in 1881 in an address to the International Medical Congress; at these different times and addressing different and important audiences he continued to urge the absolute necessity of a knowledge of nature. A well-known and eloquent passage from an address on "a liberal education" delivered to working men in 1868 contains the gist of his reiterated argument:

"Suppose it were perfectly certain that the life and fortune of every one of us would, one day or other, depend on his winning or losing a game of chess, don't you think that we should all consider it to be a primary duty to learn at least the names and the moves of the pieces; to have a notion of a gambit, and a keen eye for all the means of giving and getting out of check? Do you not think that we should look with a disapprobation amounting to scorn upon the father who allowed his son, or the state which allowed its members, to grow up without knowing a pawn from a knight?

"Yet it is a very plain and elementary truth, that the life, the fortune, and the happiness of every one of us, and more or less of those who are connected with us, do depend upon our knowing something of the rules of a game infinitely more difficult and complicated than chess. It is a game which has been played for untold ages, every man and woman of us being one of the two players in a game of his or her own. The chess-board is the world, the pieces are the phenomena of the universe, the rules of the game are what we call the laws of nature. The player on the other side is hidden from us. We know that his play is always fair, just, and patient. But also we know, to our cost, that he never overlooks a mistake, or makes the smallest allowance for ignorance. To the man who plays well, the highest stakes are paid, with that sort of overflowing generosity with which the strong shows delight in strength, and one who plays ill is checkmated—without haste, but without remorse."

Huxley wished that this scientific education should begin at an early period of every child's training. In 1869 he wrote:

"Let every child be instructed in those general views of the phænomena of nature for which we have no exact English name. The nearest approximation to a name for what I mean which we possess is physical geography; the Germans have a better, 'Erdkunde' (earth knowledge or geology in its etymological sense), that is to say, a general knowledge of the earth, and what is on it and in it and about it. If anyone who has experience of the ways of young children will call to mind their questions, he will find that so far as they can be put in any scientific category, they will come under this head of 'Erdkunde.' The child asks, 'What is the moon, and why does it shine?' 'What is this water, and where does it run?' 'What is the wind?' 'What makes these waves in the sea?' 'Where does this animal live, and what is the use of that plant?' And if not snubbed and stunted by being told not to ask foolish questions, there is no limit to the intellectual craving of a young child; nor any bounds to the slow but solid accretion of knowledge and development of the thinking faculty in this way. To all such questions, answers which are necessarily incomplete, though true as far as they go, may be given by any teacher whose ideas represent real knowledge and not mere book learning: and a panoramic view of nature, accompanied by a strong infusion of the scientific habit of mind, may thus be placed within the reach of every child of nine or ten."

In 1880 Huxley, in association with Roscoe, the chemist, and Balfour Stewart, the physicist, took a great practical step toward securing the widest possible extension of elementary knowledge in science. They became general editors, for the English publishing house of Macmillan, of a series of "Science Primers." These were written in simple language, suitable for those with no preliminary knowledge of science, but were the work of the chief authorities in the leading branches of science. They were published at what was then the revolutionary price of a shilling, and they sold in very large numbers. Huxley himself wrote the introductory volume to this great series of tracts, taking for his subject the simplest and most natural phenomena of the world and the simplest chains of cause and effect that can be observed

around us. The keynote of the little book was that knowledge of nature could be gained only by observation and experiment, and that for these the ordinary things in the world around us provided ample material. A few years later he wrote a more advanced volume on the same subject. He had now found an English name for the German *Erdkunde*, and his book on *Physiography* was simply an account of the leading things and forces of nature. A traveller set down in a foreign land will at once get into difficulties unless he has provided himself with a guide to the geography, the manners and customs, and the regulations of the country in which he finds himself. Huxley's aim was to provide a similar guide to nature; an outline of elementary knowledge of the world into which we all come as strangers. He wrote of force and energy, of the forms of water, of heat and cold, of the atmosphere, of winds and tides and weather, and of the main features of the lives of plants and animals. There was nothing new in what he wrote; he simply took from the chief sciences their leading principles and elementary facts, and set them forth in plain and simple language so that all could read and understand. The novelty was that an attempt should be made to bring these facts within the reach of all. The idea proved infectious; in Europe and America, in many languages and by many authors, Huxley's main lines were followed, with the result that a new branch of education, and almost of science, was created.

The body of man and the processes of life, in the earlier part of the century, were almost as unknown to most people as were the structure of the earth and the great processes of nature. What was known of human anatomy and physiology was contained in ponderous treatises, written in difficult and technical language suitable only for students of medicine and doctors. It was thought to be not only unnecessary but slightly coarse for those not in the profession to know anything of the viscera of digestion, circulation, and so forth.

Huxley laid low this great superstition by his *Elementary Lessons in Physiology*, a little volume first published in 1866, which ran through many editions. In it he wrote primarily for teachers and learners in boys' and girls' schools, and selected from the great bulk of knowledge and opinion called human physiology only the important and well-established truths. So successful was he in his selection that, notwithstanding the immense increase in knowledge since he wrote, the book still remains an adequate and useful elementary treatise, and by this time must have given their main knowledge of the human body to hundreds and thousands of readers who otherwise would have remained ignorant.

The books of which we have been writing were addressed to the general public, but, in addition, Huxley wrote several, of which three are specially important, for those students who devote themselves specially to anatomy. *The Crayfish*, his famous volume in the International Scientific Series, has been called by Howes, the assistant and successor of Huxley at the Royal College of Science, "probably the best biological treatise ever written." Many naturalists have written elaborate monographs on single animals: Lyonet worked for years on the willow caterpillar, Strauss Durckheim devoted an even minuter attention to the common cockchafer, and the great Bojanus investigated almost every fibre in the structure of the tortoise. The volumes produced by these anatomists were valuable and memorable, and occupy an honoured place in the library of science, but Huxley's aim was wider and greater. He shewed how careful study of one of the commonest and most insignificant of animals leads, step by step, from every-day knowledge to the widest generalisations and the most difficult problems of zoology. He made study of a single creature an introduction to a whole science, and taught students to regard any form of life not merely as a highly complicated and deeply interesting anatomical study, but as a creature that is only one out of an

innumerable host of living things, every fibre in its body, every rhythm of its functions proclaiming the degree and nature of its relationship to other animals. R. Louis Stevenson, writing of his native town, tried to give "a vision of Edinburgh, not as you see her, in the midst of a little neighbourhood, but as a boss upon the round world, with all Europe and the deep sea for her surroundings. For every place is a centre to the earth, whence highways radiate, or ships set sail for foreign ports; the limit of a parish is not more imaginary than the frontier of an empire." It is this wider sweep, this attempt to see and to teach not merely the facts about things but the relations of these facts to the similar facts in other things, that makes the difference between the new knowledge and the old. The questions to be asked and answered are not merely, What are the structures in this animal? but, How and why do they come to be what they are? Huxley was a ruthless enemy of books and teachers that made the mere acquisition of details of knowledge their chief object.

"I remember," he wrote, "in my youth there were detestable books which ought to have been burned by the hands of the common hangman, for they contained questions and answers to be learned by heart, of this sort, 'What is a horse? The horse is termed *Equus caballus*; belongs to the class Mammalia; order, Pachydermata; family, Solidungula.' Was any human being the wiser for learning that magic formula? Was he not more foolish inasmuch as he was deluded into taking words for knowledge?"

Huxley himself admitted his difficulty in remembering apparently meaningless facts, and occasionally aided his memory by inventing for them a humorous significance. Howes relates a story of this kind. While examining the papers of candidates for some examination, Huxley came across one in which the mitral or biscuspid valve of the heart was erroneously described as being placed in the right cavity. "Poor little beggar,"

said Huxley, "I never could get them myself until I reflected that a bishop could never be in the right." This insistence on the uselessness of formal knowledge applied only to those who were being taught or who were learning from books or lectures. Of the value and discipline of knowledge of facts gained at first hand from objects themselves either in original investigation or with the aid of books, Huxley had the highest possible opinion. By such a method of work alone he believed it possible to distinguish what we believe on authority from what we have convinced ourselves to be true, and, as we shall see later, he regarded it as the most important duty of a man to have acquired the habit of classifying the mass of ideas in his brain into those which he knew and those which he thought to be true from having read or heard or imagined them.

The two other of the three great treatises for anatomical students are the *Manual of the Anatomy of Vertebrated Animals*, published in 1871, and the *Manual of the Anatomy of Invertebrated Animals*, published in 1877. Of these two volumes it is sufficient to say that they formed the chief introduction to the study of animal zoology for many years, and that a large number of the best-known zoologists of the end of the nineteenth century received from them their first instruction in science. As text-books they have been superseded lately by larger volumes in which there is found more space for some of the recent advances in knowledge, especially comparative embryology, and the more intricate knowledge of the structure of the soft parts of marine invertebrates made possible by the newer and more successful methods of preserving delicate tissues. Just before Huxley ceased his regular work as a teacher at the Royal College of Science, there arrived a series of marine embryos, beautifully preserved and prepared for microscopic work by the zoologists at the International Zoological Station at Naples. Huxley is reported to have exclaimed at their beauty, and to have said: "You young men cannot realise your advantages; you

have brought to you for study at your leisure in London, creatures that I had to lash my microscope to the mast to get a glimpse of." Huxley's books were written for students with fewer advantages, and, naturally, laid more stress on the harder skeletal parts and such structures as could be more easily preserved; but with this inevitable limitation, they still serve as luminous and comprehensive guides to the subjects of which they treat. There is no doubt but that if he had been a younger man when the new technical methods made their appearance, he would have adopted them and their results in his volumes. One of the first great pieces of work which utilised methods more like those now used in all laboratories than those employed during the greater part of Huxley's life as a teacher was the classical investigation by Van Beneden into the changes in the egg of Ascaris which accompanied the process of fertilisation. When Huxley read the memoir he exclaimed, "All this by the use of glacial acetic acid—is it possible!" At once, Howes relates, he repeated the whole investigation himself, and, when satisfied, declared that the "history of the histological investigation of the future would be the history of its methods." Not only have the chemical substances used in preparing tissues for examination greatly increased since Huxley's time as an active worker, but a very important method of investigation has come into general use. In Huxley's time tissues or animals too large or too opaque to be examined microscopically as whole structures were either teased by needles or were cut with a razor by hand into comparatively thick slices. The process of cutting, however practised the operator, was tedious and uncertain, and it was almost impossible to cut a piece of tissue into a series of thin slices without losing or destroying considerable portions. Microtomes, with various accessory mechanical appliances, have now been invented, and by means of these not only are slices of great tenuity made with ease, but there is little difficulty in cutting the most delicate organism

into a ribbon of consecutive slices. Such new methods have made almost a revolution in the study of zoology, particularly of the lower forms of life and of the embryonic stages of higher animals, and books written before these methods became common have naturally been superseded.

Huxley did far more for the teaching of science than the preparation of books, however useful these were. He was the practical inventor of the laboratory system of teaching zoological science, and all over the world the methods invented by him have been adopted in university laboratories and technical schools. He had always declared that since zoology was a physical science, the method of studying it must needs be analogous to that which is followed in other physical sciences. If a man wishes to be a chemist, it is necessary not only that he should read chemical books and attend chemical lectures, but that he should actually perform the fundamental experiments in the laboratory for himself, and thus learn exactly what the words which he reads in his books and hears from his teachers, mean. "If you want a man to be a tea-merchant, you don't tell him to read books about China or about tea, but you put him into a tea-merchant's office where he has the handling, the smelling, and the tasting of tea. Without the sort of knowledge which can be gained only in this practical way, his exploits as a tea-merchant will soon come to a bankrupt termination." The great and obvious difficulty in the practical teaching of biology appeared to be the immense number of different kinds of animals and plants in existence. A human life would not suffice for the examination of a hundredth part of these. Huxley met the difficulty by the "type" system.

"There are certainly more than 100,000 species of insects, and yet anyone who knows one insect, if a properly chosen one, will be able to have a fair conception of the structure of the whole. I do not mean to say he will know that structure thoroughly, or as well as is desirable that he should know it; but he will have enough real knowledge to enable him to

understand what he reads, to have genuine images in his mind of these structures which become so variously modified in all the forms of insects he has not seen. In fact, there are such things as types of form among animals and vegetables, and for the purpose of getting a definite knowledge of what constitutes the leading modifications of animal and plant life, it is not needful to examine more than a comparatively small number of animals and plants."

The type system in itself was not absolutely new. Rolleston, the Linacre professor at Oxford, in his *Forms of Animal Life* had devised the method of teaching comparative anatomy by the study of a graded series of animals. But his method depended on the existence of a series of dissections and preparations made by a skilled craftsman; the tradition of teaching by authority instead of by investigation was maintained, although the authority of books and lectures was aided by museum specimens in glass bottles, the actual basis of the book being a series of dissections prepared by Charles Robertson, Rolleston's laboratory assistant, for the great International Exhibition of 1861. The authorities of Huxley's students were to be found in nature itself. The green scum from the nearest gutter, a handful of weed from a pond, a bean-plant, some fresh-water mud, a frog, and a pigeon were the ultimate authorities of his course. His students were taught how to observe them, and how to draw and record their observations. However familiar the objects, each student had to verify every fact afresh for himself. The business of the teacher was explanation of the methods of verification, insistence on the accomplishment of verification. It was a training in the immemorial attitude of the scientific mind, codified by Huxley and made an integral part in the national education.

Although he arranged laboratory teaching, he had to leave most of the details to his assistants, and his own visits to the laboratory were often rather dreaded by the students. Professor H. F. Osborn relates that on one occasion "there was an

Irish student, who sat in front of me, whose anatomical drawings in water-colour were certainly most remarkable productions. Huxley, in turning over his drawing-book, paused at a large blur, under which was carefully inscribed, "sheep's liver," and smilingly said, "I am glad to know that it's a liver; it reminds me as much of Cologne Cathedral in a fog as of anything I have ever seen before" ("Life and Letters," II. p. 413).

As a matter of fact it was comparatively late in his life as a teacher that Huxley had complete opportunity for putting into practice his scheme for the laboratory teaching of biology. In 1854 there was no laboratory attached to the Natural History Department of the School of Mines. Lectures alone were given, and the only opportunity the student had of practical acquaintance with the facts was in a short interview with the professor at the lecture table after the lecture. This condition continued practically to 1872. But a few years before that Huxley and his colleagues drew up a memorandum deploring the existing state of affairs. In his evidence before the Royal Commission of 1870 Huxley said: "There is a complete want in the School of Mines, as it now exists, of any means of teaching several of the subjects practically. For example, I am set there to teach natural history without a biological laboratory and without the means of shewing a single dissection." Against strong internal opposition and at considerable pecuniary loss Huxley and some of his colleagues succeeded, in 1872, in getting the School of Mines transferred to South Kensington, where it became the Royal College of Science. For the first course of instruction given in the new buildings, Huxley obtained the aid of M. Foster, Rutherford, and Ray Lankester. The laboratory course originated by Huxley and shaped by him with these three distinguished assistants became the model of the regular courses given subsequently, and, with various slight modifications, has since been adopted almost universally. Later on, Huxley described it as follows:

"I lecture to a class of students daily for about four months and a half, and my class have, of course, their text-books; but the essential part of the whole teaching, and that which I regard as really the most important part of it, is a laboratory for practical work, which is simply a room with all the appliances needed for ordinary dissection. We have tables properly arranged in regard to light, microscopes and dissecting instruments, and we work through the structure of a certain number of plants and animals. As, for example, among the plants we take the yeast-plant, a Protococcus, a common mould, a Chara, a fern, and some flowering plant; among animals we examine such things as an Amœba, a Vorticella, and a fresh-water polyp. We dissect a starfish, an earthworm, a snail, a squid, and a fresh-water mussel. We examine a lobster and a crayfish, and a black beetle. We go on to a common skate, a codfish, a frog, a tortoise, a pigeon, and a rabbit, and that takes us about all the time we have to give. The purpose of this course is not to make skilled dissectors, but to give every student a clear and definite conception, by means of sense images, of the characteristic structure of each of the leading modifications of the animal kingdom; and that is perfectly possible by going no further than the length of that list of forms which I have enumerated. If a man knows the structure of the animals I have mentioned, he has a clear and exact, however limited, apprehension of the essential features of the organisation of all those great divisions of the animal and vegetable kingdoms to which the forms I have mentioned severally belong. And it then becomes possible to him to read with profit; because every time he meets with the name of a structure, he has a definite image in his mind of what the name means in the particular creature he is reading about, and therefore the reading is not mere reading. It is not mere repetition of words; but every term employed in the description, we will say of a horse, or of an elephant, will call up the image of the things he had seen in the rabbit, and he is able to form a distinct conception of that which he has not seen, as a modification of that which he has seen."

Huxley himself was originally a medical man; all through his life he was interested in the biological sciences that underlie a scientific practice of medicine, and as teacher and examiner he had much to do with the shaping of medical

education in London. Acting in various public capacities, as a member of commissions dealing with medical education, or as a witness before them, in magazine articles and in public speeches he made many contributions to the problems to be faced in medical education. Some of these related to the conditions peculiar to medical training in London. In the greatest city of the world there was during Huxley's life and there is still nothing comparable with the great universities of Europe and America, of Scotland and Ireland. Some dozen hospitals, supported partly by endowments, partly by charities, attempt each to maintain a complete, independent medical school. As the requirements of medical education in staff, laboratories, and general equipment have advanced, these hospitals have made heroic efforts to advance with them. Notwithstanding the zeal and public spirit of the staff and managers of the hospitals, this want of system has naturally resulted in a multiplication of inefficient institutions and a number of makeshift arrangements. Huxley repeatedly urged the concentration of all this diffuse effort into a few centres, but this inevitable reform has not yet become possible.*

A second important consideration, and one that has a much wider application, relates to the kind of person by whom the scientific sides of medical teaching should be given. Primitively, all the instruction to medical students was given by those actually engaged in the practice of medicine. Huxley was strongly of the opinion that the teachers of anatomy, physiology, chemistry, and so forth, should be specialists devoted to these subjects for life, and not merely surgeons and physicians who engaged in teaching until their practice grew sufficiently to monopolise their attention.

"I get every year," he said, "the elaborate reports of Henle and Meissner—volumes of I suppose 400 pages altogether—and they consist merely of abstracts

* [This comment, written in 1900, remains practically true in 1912, P.C.M.]

of the memoirs and works which have been written on Anatomy and Physiology—only abstracts of them. How is a man to keep up his acquaintance with all that is doing in the physiological world—in a world advancing with enormous strides every day and every hour—if he has to be distracted with the cares of practice?"

There would always be found men, he declared, who would make the choice between the wealth which may come by successful practice and a modest competency, when that modest competency was to be combined with a scientific career and the means of advancing knowledge. It was to those who made the latter choice that he would entrust the teaching of the sciences underlying medicine; partly because such men would be better able to keep pace with the most recent advances in knowledge, and partly because their teaching would be stimulated by their own scientific research. In this great matter the world is rapidly advancing towards the standard of Huxley; as each new appointment is made it becomes more and more probable that the man chosen will be a teacher and investigator rather than a practitioner.

In another general question of the politics of medical education Huxley took a strong line, and the tendency of change is toward his view. One of the first results of the awakening of medical education in the middle of this century was a tendency to throw an almost intolerable burden of new subjects upon the medical student. In the revolt from the old apprenticeship system, in which the student, from the very first, gave his chief attention to practice, and was left almost to himself to pick up a scanty knowledge of the principles and theories underlying his profession, the pendulum swung too far the other way, and there was almost no branch of the biological and physical sciences in which he was not expected to go through a severe training. On the old system the greater part of his time was spent in the wards of the hospital; on the new system it was only at an advanced stage of his career that he entered the wards

at all, a great part of his time and energy being spent in the purely scientific work of the medical college. Huxley, although he had largely aided in the overthrow of the happy-go-lucky older system, of which Mr. Bob Sawyer was no exaggerated type, was equally severe on the reckless extensions of the new system. "If I were a despot," he said, "I would cut down the theoretical branches to a very considerable extent." He would discard comparative anatomy and botany, materia medica, and chemistry and physics, except as applied to physiology, from the medical student's course. At first sight, this seems a hard saying, but it is to be remembered that at that time the normal curriculum of a medical student lasted only four years, a space of time barely sufficient for the necessary minimum of purely medical and surgical work. Huxley's view was that chemistry and physics, botany and zoology, should be part of the general education, not of the special medical education; he wished students to spend one or two years after their ordinary career at school in work on these elementary scientific subjects, and then to begin their medical course free from the burden of extra-professional subjects. With certain limits due to the different local conditions in different teaching centres Huxley's system is being adopted. In most cases the authorities in medical education are unable to leave the whole responsibility of the elementary education in science to the schools from which medical students come, as the conditions under which scientific subjects are taught in schools leave still much to be desired. The average length of the medical curriculum has been extended and the elementary scientific subjects are taken first, sometimes at the medical colleges, sometimes in the scientific departments of universities. The interesting general point of view is that Huxley, although himself a biologist and teacher of biology, took too broad an outlook on the general policy of education to insist upon his own subject to the detriment of the precise practical objects of the training of medical students.

In a letter to Sir Ray Lankester, written in 1892, Huxley summarised his objection to throwing too great a burden of scientific study on the average medical student. "Our side has been too apt to look on medical schools as feeders for science. They have been so, but to their detriment as medical schools. And now that so many opportunities for purely scientific training are afforded, there is no reason they should remain so.

"The problem of the medical university is to make an average man into a good practical doctor before he is twenty-two, and with not more expense than can be afforded by the class from which doctors are recruited, and than will be rewarded by the prospect of an income of £400 to £500 a year.

"It is not right to sacrifice such men, and the public on whom they practise, for the prospect of making one per cent of medical students into men of science." (Life and Letters, II. p. 310.)

In the days of Huxley's greatest activity, while by the natural force of events and by his special efforts science was becoming more recognised as a necessary and important branch of general education, the cry was raised against it that scientific education was not capable of giving what is called culture. A scientific man was regarded as a mere specialist, and science was considered to have no place in, and in fact to be an enemy of, "liberal education." In 1880, at Birmingham, Huxley attacked this view in a speech delivered at the opening of the Mason College. Sir Josiah Mason, the benevolent founder of that great institution, had made it one of the conditions of the foundation that the College should make no provision for "mere literary instruction and education." This gave Huxley a text for raising the whole question of the relation of science to culture. He declared that he held very strongly by two convictions.

"The first is, that neither the discipline nor the subject-matter of classical education is of such direct value to the student of physical science as to justify the expenditure of valuable time on either; and the

second is, that for the purpose of attaining real culture, an exclusively scientific education is at least as effectual as an exclusively literary education."

He quoted from Matthew Arnold, then in the zenith of his fame as a chief apostle of culture, and shewed that there were two propositions involved in the "literary" view of culture. The first was that a "criticism of life" was the essence of culture; the second, that literature contained the materials which sufficed for the construction of such a criticism. With the first proposition he had no dispute, taking the view that culture was something quite different from learning or technical skill. "It implies the possession of an ideal, and the habit of critically estimating the value of things by comparison with a theoretic standard. Perfect culture should supply a complete theory of life, based upon a clear knowledge alike of its possibilities and its limitations." Against the second proposition he urged in the first place that it was self-evident that after having learned all that Greek, Roman, and Eastern antiquity have thought and said, and all that modern literature has to tell us, it was still necessary to have a deeper foundation for criticism of life. An acquaintance with what physical science had done, particularly in later years, was as necessary to criticism of life as any of the literary materials. Next, following the biological habit of examining anything by studying its development, he shewed how the connection between "culture" and study of classical literature had come into existence. For many centuries Latin grammar, with logic and rhetoric, studied through Latin, were the fundamentals of education. A liberal education was possible only through study of the language in which all or nearly all the materials for it were written. With the changes produced by the Renaissance there came a battle between Latin and Greek, and Greek came to be part of a liberal education. Later on, there came a similar battle between the classical and modern languages, and now the modern languages have included and absorbed all

the necessary material for knowledge and criticism. Those who cling to classics as the basis of culture and education are clinging to old weapons long after these have ceased to be effective, simply because at one time in history these were the only weapons available in the struggle for knowledge.

CHAPTER XI

GENERAL PROBLEMS OF EDUCATION

IN the last chapter, the special relation of Huxley to scientific education was described, and it is in connection with such education that his influence is best known. But he was keenly interested in the larger problems of general, university, and technical education, and he played a great part in shaping the lines upon which these have been solved in England.

In the years immediately before 1870, all England was wrestling with the great problem of elementary education, in the arrangements for which it was far behind not only the leading European countries but even its sister-kingdom, Scotland. In 1870 there came into operation an Act of Parliament for the regulation of elementary education under the supervision of locally elected school boards. Hitherto elementary education had been controlled by the Established Church, and by other denominational religious bodies, and the quality and quantity of the instruction provided, for financial and various other reasons, had been extremely unsatisfactory. But a long and furious battle had raged around the religious question; elementary education was now to be national, compulsory, and universal; where religious bodies maintained schools that complied with certain fixed standards of efficiency, attendance of children at these was to be regarded as satisfactory, and in addition to the ordinary subjects, such theological and religious teaching as the supporting bodies chose might be added. But in the schools for all and sundry, under the control

of boards representing the whole population, and deriving from public rates levied on the whole population the part of their income represented by the subscriptions of the religious bodies in the denominational schools, was any definite creed to be inculcated? The extreme Church party held that the creed established by law in the land should be taught in these new schools; extreme supporters of other creeds, and a majority of ordinary people of all creeds or of no creeds, objected to a new establishment of a sectarian doctrine, even though that sectarian doctrine were the doctrine of the national church. The final result of the dispute as codified in the Act of Parliament was known as the Cowper-Temple Clause: "No religious catechism or religious formulary which is distinctive of any particular denomination shall be taught in the school." The actual value of any clause, however it may appear to be a fair compromise, depends on the spirit in which it is practically interpreted, and no sooner had the Act been passed than the battle was renewed again over the interpretation of the clause. Many of the Church controversialists held that the liberal or more advanced party intended to exclude all reference to the Bible or to religion, on the plea that some sect could be found to which the most attenuated expression of religion would appear to be against the plain meaning of the clause, and Huxley, who had been in the forefront of the controversy, and who was a candidate for the first London School Board, was decried as an enemy of the Bible and of all religion and morality because he had advocated what he called a secular interpretation of the clause. In an article published in the *Contemporary Review* immediately after the election, Huxley explained precisely what he took the clause to mean, and, afterwards, at all events during the existence of the Board to which he was elected, succeeded in carrying out his intentions in the main.

His first general point was to deprecate the action of those extremists of both sides who tried to make the education of children a battle-ground of

religious dogma. He then laid down what he conceived to be the lines of most general utility upon which, under the provisions of the Act, the education of children should be conducted. In the foreground he placed physical training and drill, as of supreme importance to young children, especially in the case of the poor children of large towns.

"All the conditions of the lives of such are unfavourable to their physical well-being. They are badly lodged, badly housed, badly fed, and live from one year's end to another in bad air, without a chance of a change. They have no playgrounds; they amuse themselves with marbles and chuck-farthing, instead of cricket and hare-and-hounds; and if it were not for the wonderful instinct which leads all poor children of tender years to throw themselves under the feet of cab-horses whenever they can, I know not how they would learn to use their limbs with agility."

This, humanitarianism as it was, was not the mere emotional sentiment of the typical humanitarian; he went on to give the soundest practical reasons for physical development.

"Whatever doubts people may entertain about the efficacy of natural selection, there can be none about artificial selection; and the breeder who should attempt to make, or keep up, a fine stock of pigs, or sheep, under the conditions to which the children of the poor are exposed, would be the laughing-stock even of the bucolic mind. Parliament has already done something in this direction by declining to be an accomplice in the asphyxiation of school children. It refuses to make any grant to a school in which the cubical contents of the school-room are inadequate to allow of proper respiration."

He wished to see physical training put on the same system.

The second point upon which he laid stress was the necessity of providing training in domestic economy, cookery, and other household accomplishments, for girls. These demands seem simple and obvious, now that by his efforts and the efforts of others they have been accomplished, but in England,

even thirty years ago, it required more than an ordinary prevision and boldness to insist upon them.

Huxley passed next to the burning question of the time. He treated it in the broadest and least sectarian spirit.

"The boys and girls for whose education the School Boards have to provide, have not merely to discharge domestic duties, but each of them is a member of a social and political organisation of great complexity, and has, in future life, to fit himself into that organisation, or be crushed by it. To this end it is surely needful, not only that they should be made acquainted with the elementary laws of conduct, but that their affections should be trained, so as to love with all their hearts that conduct which tends to the attainment of the highest good for themselves and their fellow-men, and to hate with all their hearts that opposite course of action which is fraught with evil."

He then proceeded to point out the distinction between the affection which is called religion, and the science which is called theology, and, without entering into the question as to whether the latter were or were not a true science, he insisted on the danger of a confusion between the two.

"We are divided into two parties—the advocates of so-called 'religious' teaching on the one hand, and those of so-called 'secular' teaching on the other. And both parties seem to me to be not only hopelessly wrong, but in such a position that if either succeeded completely, it would discover, before many years were over, that it had made a great mistake and done serious evil to the cause of education. For, leaving aside the more far-seeing minority on either side, what the religious party is crying for is mere theology, under the name of religion; while the secularists have unwisely and wrongfully admitted the assumption of their opponents, and demand the abolition of all religious teaching, when they only want to be free of theology—burning your ship to get rid of the cockroaches." . . . "If I were compelled to choose for one of my own children, between a school in which real religious instruction is given, and one without it, I should prefer the former, even though the child might have to take a good deal of theology

with it. Nine-tenths of a dose of bark is mere half-rotten wood; but one swallows it for the sake of the particles of quinine, the beneficial effect of which may be weakened, but is not destroyed, by the wooden dilution, unless in the case of a few exceptionally tender stomachs. Hence, when the great mass of the English people declare that they want to have the children in the elementary schools taught the Bible, and when it is plain from the terms of the Act, the debates in and out of Parliament, and especially the emphatic declarations of the Vice-President of the Council that it was intended that such Bible-teaching should be permitted, unless good cause for prohibiting it could be shewn, I do not see what reason there is for opposing that wish."

He went on to explain that, although he had always been strongly in favour of secular education, by that term he meant only education without theology, and he praised the English Bible in language as noble as has ever been applied to it by the most ardent of theologians.

"The Pagan moralists lack life and colour, and even the noble Stoic, Marcus Antonius, is too high and refined for an ordinary child. Take the Bible as a whole; make the severest deductions which fair criticism can dictate for shortcomings and positive errors; eliminate, as a sensible lay-teacher would do, if left to himself, all that is not desirable for children to occupy themselves with; and there still remains in this old literature a vast residuum of moral beauty and grandeur. And then consider the great historical fact that, for three centuries, this book has been woven into the life of all that is best and noblest in English history; that it has become the national epic of Britain, and is as familiar to noble and simple, from Land's End to John-o'-Groat's House, as Dante and Tasso once were to the Italians; that it is written in the noblest and purest English, and abounds in exquisite beauties of mere literary form; and, finally, that it forbids the veriest hind who never left his village to be ignorant of the existence of other countries and other civilisations, and of a great past, stretching back to the furthest limits of the oldest nations in the world. By the study of what other book could children be so much humanised and made to feel that each figure in that vast historical proces-

sion fills, like themselves, but a momentary space in the interval between two eternities; and earns the blessings and the curses of all time, according to its effort to do good and hate evil, even as they also are earning their payment for their work."

Lastly, he laid down the lines of the general education to be given. He pointed out that already in the existing schools a very considerable burden of work was imposed on the children in the form of catechism, lists of the kings of Israel, geography of Palestine, and that when these fantastic modes of education had been eliminated there was plenty of time and energy to be employed. The instruction in physical training was more than half play; that in the domestic subjects had an engrossing interest of its own. He proposed, first, the necessary discipline in the means for acquiring knowledge, the tools for employing it, that is to say, reading, writing, and arithmetic. After that, he believed that a certain amount of knowledge, of intellectual discipline, and of artistic training should be conveyed in the elementary schools, and for these purposes he proposed to teach some rudiments of physical science, drawing, and singing.

In many respects the progress of primary education in England has been continuous along the lines suggested by Huxley, who may be regarded as in this fashion one of the great shapers of the destinies of his race, for nothing can have a bearing more important on the character and fate of a race than the manner of training provided for the masses of individuals composing it. It is only with regard to religious instruction that the course of events has been widely different from the neutral exposition of the Bible as suggested by him. In 1870 a great majority of the people of England who reflected upon the matter at all, and all those who accepted current ideas without reflection, accepted the Bible as an inspired, direct, and simple authority on all great matters of faith and morality. Therefore, when Huxley, as by far the most important man among those who advocated a secular education, was an advocate and not in the least

an opponent of Bible teaching, they were well content to let the matter rest. There were, it is true, a certain number of zealots who entered the boards with the avowed purpose, on the one hand, of getting as much dogmatic teaching and interpretation added as it might be possible to smuggle in, and, on the other, to reduce the simplest Bible teaching to a minimum. But the vast majority of persons were out of sympathy with these fanaticisms. Since 1870, however, a gradual change has occurred in the English attitude to the Bible. The growth of the new criticism and of knowledge of it have produced the result that now only a small minority of reflecting people in England accept the Bible in the old simple way; most people think that it requires interpretation and explanation by the authority of the Church. And so a new battle over dogma has begun; moderate churchmen no longer accept the compromise of Huxley, but strive for an interpretation which must be dogmatic, and there is a new dispute as to what may be regarded as undenominational religion. When a majority of reasonable persons accepted Huxley's suggestions of simple Bible teaching they did so not because they believed, as he did, that the Bible was simply great literature, great tradition, and great morality, but because they believed it to be direct, inspired authority. It is a curious coincidence that Huxley himself did so much to spread knowledge of the new criticism, and that a first result of this diffusion was to overthrow the compromise arranged largely by his influence, which for many years provided a middle way in which sensible persons avoided the extremes of theological and anti-theological zealots.

Early in the course of his career as a member of the London School Board, Huxley crystallised his views as to the general policy of education in a phrase which perhaps has done more than any other phrase ever invented to bring home to men's minds the ideal of a national system of education. "I conceive it to be our duty," he said, "to make a ladder from the gutter to the university along

which any child may climb." We have seen the nature of his views as to the lowest rungs of this ladder; we may now turn to his work and views as to the higher stages. He expressed these views in occasional speeches and articles, and he had many important opportunities in aiding to carry them into actual practice. He was a member of a number of important Royal Commissions; Commission on the Royal College of Science for Ireland, 1866; Commission on Science and Art Instruction in Ireland, 1868; Royal Commission on Scientific Instruction and the Advancement of Science, 1870-75; Royal Commission to enquire into the Universities of Scotland, 1876-78; Royal Commission on the Medical Acts, 1881-82. From the beginning, he was closely associated with the Science and Art Department, the operations of which threw a web of education, intermediate between primary and university education, all over Britain. A number of the teachers under that department were trained by him, and as examiner to the department he took the greatest care to reduce to a minimum the evils necessarily attendant on the mode of payment by results. A certain number of teachers made it their chief effort to secure the largest possible number of grants. Huxley regarded these as poachers of the worst kind, and did all he could to foil them. He did his best to promote systematic practical instruction in the classes, and to aid teachers who desired to learn their business more thoroughly. He insisted again and again upon the popular nature of the classes; their great advantage was that they were accessible to all who chose to avail themselves of them after working hours, and that they brought the means of instruction to the doors of the factories and workshops. The subjects which he considered of most importance were foreign languages, drawing, and elementary sciences, and he wished them to be used first of all by those who were handicraftsmen and who therefore left the elementary schools at the age of thirteen or fourteen.

In a lecture given at the formal opening of the Johns Hopkins University at Baltimore in 1876, and

in a Rectorial address to the University of Aberdeen two years earlier, Huxley laid down the general lines of university education as he conceived it. He began by supposing that a good primary education had already been received.

"Such an education should enable an average boy of fifteen or sixteen to read and write his own language with ease and accuracy, and with a sense of literary excellence derived from the study of our classic writers; to have a general acquaintance with the history of his own country and with the great laws of social existence; to have acquired the rudiments of the physical and psychological sciences, and a fair knowledge of elementary arithmetic and geometry. He should have obtained an acquaintance with logic rather by example than by precept; while the acquirement of the elements of music and drawing should have been a pleasure rather than work."

He had not much to say for secondary or intermediate education, partly because at that time, in England at least, the secondary schools were in a hopeless state of incapacity, and differed from primary schools not only in their greater expense, their adaptation to the class-spirit which demanded the separation of the boys of the upper and middle classes from those in the lower ranks of society, but chiefly in the futility of the education given at the majority of them. But where intermediate schools did exist, he demanded that they should keep on the same wide track of general knowledge, not sacrificing one branch of knowledge for another. He held that the elementary instruction to which he had referred embraced all the real kinds of knowledge and mental activity possible to man. The university could add no new fields of mental activity, no new departments of knowledge. What it could do was to intensify and specialise the instruction in each department.

"Thus literature and philology, represented in the elementary school by English alone, in the university will extend over the ancient and modern languages. History, which like charity, best begins at home, but,

like charity, should not end there, will ramify into anthropology, archæology, political history, and geography, with the history of the growth of the human mind and of its products, in the shape of philosophy, science, and art, and the university will present to the student libraries, museums of antiquities, collections of coins, and the like, which will efficiently subserve these studies. Instruction in the elements of political economy, a most essential but hitherto sadly neglected part of elementary education, will develop in the university into political economy, sociology, and law. Physical science will have its great divisions, of physical geography, with geology and astronomy; physics; chemistry and biology; represented not merely by professors and their lectures, but by laboratories in which the students, under guidance of demonstrators, will work out facts for themselves and come into that direct contact with reality which constitutes the fundamental distinction of scientific education. Mathematics will soar into its highest regions; while the high peaks of philosophy may be scaled by those whose aptitude for abstract thought has been awakened by elementary logic. Finally, schools of pictorial and plastic art, of architecture, and of music will offer a thorough discipline in the principles and practice of art to those in whom lies nascent the rare faculty of æsthetic representation, or the still rarer powers of creative genius."

Early in the seventies the problems connected with what is called technical education became prominent in the minds of the most far-seeing of this nation. It was plain that England was not advancing with the same strides as some other nations in arts and manufactures, and the most obvious difference between England and the rivals whose advance was causing anxiety lay in her deficiency in education. Science or knowledge of nature lies at the root of all the arts and manufactures, and it was our relation to scientific teaching and research that required investigation. Huxley took the keenest interest in this question and made large contributions to its solution, contributions which have not yet been put completely into operation. He insisted most strongly upon a point that we as a nation have not yet completely

grasped. There is no difference between applied science and any other kind of science. The chemistry of manufactures, the physics of industrial machinery, the biology of agriculture and of fisheries, are not different from other chemistries and physics and biologies. They are merely special cases of the application of the same general fund of knowledge, and the same general principles of investigation. Huxley wished that the term "applied science" had never been invented, or that it could be destroyed. A man cannot study the chemistry of dyeing or make advances in it unless he be a thoroughly trained chemist in the full sense of the word. More than that, many of the greatest discoveries, using the word "great" as applied to commercial advantage rather than to abstract progress in knowledge, have been made by those who were pursuing research for its own sake rather than for any immediate commercial advantage to be derived from it. Hence he regarded it of vital importance, from the mere point of view of the prosperity of the country, that there should be a sufficiently large number of scientific men provided with the means for research in the shape of income and appliances. The most immediately utilitarian fashion for the nation to encourage science, was to encourage it in its highest and most advanced aspects. This meant the endowment of research and the support of institutions in which research might be conducted, and Huxley strove unceasingly for the benefit of all such great organisations. One of the last public occasions of his life was his appearance as leader of a deputation to urge upon the government the formation of a real university in London which should unite the scattered institutions of that great city and promote the highest spheres of the pursuit of knowledge. He held the view, strongly, that a useful combination was to be made by uniting the functions of teaching and investigation. A teacher taught better when his mind was kept fresh by the advances he himself was making, and an investigator, by having a moderate amount of teaching to do, gained from the

need of forcing his mind from time to time to take broad surveys of the whole field, a part of which he was engaged in tilling. The first great object, then, in promoting science so as to reap the most direct national advantage from it, was to encourage science in its highest and widest forms. It cannot be said that England has yet learned this lesson. The number of institutions in Germany where advanced investigation is continuously pursued is absolutely and relatively greater than the number in England.

The second part of technical education is that to which general attention is more commonly given. It consists of the kind of training to be given to the great army of workers in the country. In regard to this, as in regard to research work, Huxley insisted on the absence of distinction between technical or applied science and science without such a limiting prefix. So far as technical instruction meant definite teaching of a handicraft, he believed that it could be learned satisfactorily only in the workshop itself.

"The workshop is the only real school for a handicraft. The education which precedes that of the workshop should be entirely devoted to the strengthening of the body, the elevation of the moral faculties, and the cultivation of the intelligence; and, especially, to the imbuing of the mind with a broad and clear view of the laws of that natural world with the components of which the handicraftsman will have to deal. And, the earlier the period of life at which the handicraftsman has to enter into the actual practice of his craft, the more important is it that he should devote the precious hours of preliminary education to things of the mind, which have no direct and immediate bearing on his branch of industry, though they lie at the foundation of all the realities."

He compared his own handicraft as an anatomist with the handicrafts of artisans, and declared that the kind of preliminary training he would choose for himself or for his pupils was precisely the training he would provide for them. He did not wish that one who proposed to be a biologist should learn dissection during his school-days; that would come

later, and, in the meantime, broader and deeper foundations had to be laid. These were the ordinary subjects of a liberal education: physical training, drawing, and a little music, French and German, the ordinary English subjects, and the elements of physical science. Against such costly schemes of education for the whole population of a nation, many objections have been urged. Of these, perhaps the chief is that the majority of human beings even in the most civilised country are not capable of profiting by or taking an interest in, or certainly of advancing far in, most subjects. Huxley met such objections in a spirit of the widest statesmanship. There were two reasons for making the general education of all what he called a liberal education. The first was that, even in a liberal education such as he advocated, no subject was pursued beyond the broad elementary stages, and that during the early years of life, while the framework and the character were forming, it was of first-rate importance not to stunt either by lack of material. The second great principle was, that until any individual had had the opportunity, it was impossible to say whether or no he would profit much or little, and the gain to the whole nation by not missing any of those who were born with unusual natural capacity was more than worth the cost of affording opportunities to all.

"The great mass of mankind have neither the liking, nor the aptitude, for either literary or scientific or artistic pursuits; nor, indeed, for excellence of any sort. Their ambition is to go through life with moderate exertion and a fair share of ease, doing common things in a common way. And a great blessing and comfort it is that the majority of men are of this mind; for the majority of things to be done are common things, and are quite well enough done when commonly done. The great end of life is not knowledge but action. What men need is as much knowledge as they can assimilate and organise into a basis for action; give them more and it may become injurious. One knows people who are as heavy and stupid from undigested learning as others are from over-fullness of meat and drink. But a

small percentage of the population is born with that most excellent quality, a desire for excellence, or with special aptitude of some sort or another. . . . Now, the most important object of all educational schemes is to catch these exceptional people, and turn them to account for the good of society. No man can say where they will crop up; like their opposites, the fools and the knaves, they appear sometimes in the palace, and sometimes in the hovel; but the great thing to be aimed at, I was almost going to say, the most important end of all social arrangements, is to keep these glorious sports of Nature from being either corrupted by luxury or starved by poverty, and to put them into the position in which they can do the work for which they are specially fitted. . . . I weigh my words when I say that if the nation could purchase a potential Watt or Davy or Faraday, at the cost of a hundred thousand pounds down, he would be dirt cheap at the money."

The beginning and end of the whole matter was that a national system of education was above all things a "capacity-catcher," designed to secure against the loss of the incalculable advantages to be gained by cultivating the best genius born in the land.

CHAPTER XII

CITIZEN, ORATOR, AND ESSAYIST

A GREAT body of fine work in science and literature has been produced by persons who may be described as typically academic. Such persons confine their interest in life within the boundaries of their own immediate pursuits; they are absorbed so completely by their avocations that the hurly-burly of the world seems needlessly distracting and a little vulgar. No doubt the thoughts of those who cry out most loudly against disturbance by the intruding claims of the world are, for the most part, hardly worth disturbing; the attitude to extrinsic things of those who are absorbed by their work is aped not infrequently by those who are absorbed only in themselves. None the less it is important to recognise that a genuine aversion from affairs is characteristic of many fine original investigators, and it is on such persons that the idea of the simple and childlike nature of philosophers, a simplicity often reaching real incapacity for the affairs of life, is based. There was no trace of this natural isolation in the character of Huxley. He was not only a serious student of science but a keen and zealous citizen, eagerly conscious of the great social and political movements around him, with the full sense that he was a man living in society with other men and that there was a business of life as well as a business of the laboratory. We have seen with what zeal he brought his trained intelligence to bear not only on his own province of scientific education, but on the wider problems of general education, and yet the time he gave to these was

only a small part of that which he spared from abstract science for affairs. In scientific institutions as in others, there is always a considerable amount of business, involving the management of men and the management of money, and Huxley's readiness and aptitude led to his being largely occupied with these. For many years he was Dean of the Royal College of Science at South Kensington, and for a considerable time he served the Geological Society and the Royal Society as secretary. In these posts, Huxley displayed great capacity as a leader of men and as a manager of affairs, and contributed largely to the successful working of the institutions which he served.

In England, when troublesome questions press and seem to call for new legislation, it frequently happens that the collection and sifting of evidence preliminary to legislation is a task for which the methods and routine of Parliament are unsuitable. The Sovereign, acting through responsible advisers, appoints a Royal Commission, consisting of a small body of men, to which is entrusted the preliminary task of collecting and weighing evidence, or of making recommendations on evidence already collected. To such honourable posts Huxley was repeatedly called. He served on the following Commissions: 1. Royal Commission on the Operation of Acts relating to Trawling for Herrings on the Coast of Scotland, 1862. 2. Royal Commission to Enquire into the Sea Fisheries of the United Kingdom, 1864-65. 3. Commission on the Royal College of Science for Ireland, 1866. 4. Commission on Science and Art Instruction in Ireland, 1868. 5. Royal Commission on the Administration and Operation of the Contagious Diseases Acts, 1870-71. 6. Royal Commission on Scientific Instruction and the Advancement of Science, 1870-75. 7. Royal Commission on the Practice of Subjecting Live Animals to Experiments for Scientific Purposes, 1876. 8. Royal Commission to Enquire into the Universities of Scotland, 1876-78. 9. Royal Commission on the Medical Acts, 1881-82. 10. Royal Commission on Trawl, Net, and Beam-Trawl Fishing,

1884. This is a great record for any man, especially for one in whose life work of this kind was outside his habitual occupation. It was no doubt in special recognition of the important services given his country by such work, as well as in general recognition of his distinction in science, that he was sworn a member of Her Majesty's Privy Council, so attaining a distinction more coveted than the peerage.

The voluminous reports of the Commissions shew that Huxley, very far from being a silent member of them, took a large part in framing the questions which served to direct witnesses into useful lines, and that his clear and orderly habit of thought proved as useful in the elucidation of these subjects as they were in matters of scientific research. For the most part, the problems brought before the Commissions have lost their interest for readers of later years, but there are matters still unsettled on which the opinions of Huxley as expressed then remain useful. The Commission of 1876, for instance, dealt with vivisection, a matter on which the conscience of the ordinary man is not yet at rest. Although Huxley was intensely interested in the problems of physiology, and although at one time he hoped to devote his life to them, fortune directed otherwise, and the investigations for which he is famed did not involve the kind of experiments known as vivisection. The greater part of his work was upon the remains of creatures dead for thousands of years or upon the lifeless skeletons of modern forms. On the other hand, he was keenly interested in the progress of physiological science, he had personal acquaintance with most of the distinguished workers in physiology of his time at home and abroad, and from this knowledge of their character and aspirations he was well able to judge of the reckless accusations brought against them. He was a man full of the finest humanity, with an unusual devotion to animals as pets, and with knowledge of the degrees of pain involved in experimenting on living creatures. He insisted strongly on the necessity of limiting or abolishing pain, wherever it was possible; he agreed that any

experiments which involved pain should not be permitted for the purpose of demonstrating known elementary facts. But, from his knowledge of the benefits which had been gained from experimental research, and from his confidence in those who conducted it, he declined to give support to the fanatics who desired to make such experimental research a penal offence, even when conducted by the most skilled experts for the highest purposes.

Huxley contributed his share to the great questions which agitated the public not only by service on Commissions, but by delivering a large number of public addresses and writing many essays on topics of special interest. Much of his work on scientific, educational, and general subjects took its first shape in the form of addresses given to some public audience. University audiences in England, Scotland, and America were familiar to him, and from time to time he addressed large gatherings of a mixed character. But probably his favourite audience was composed of working men, and he had the greatest respect for the intelligence and sympathy of hearers who like himself passed the greater portion of their time in hard work. Howes, his pupil, friend, and successor, writes of him :

"He gave workmen of his best. The substance of *Man's Place in Nature*, one of the most successful and popular of his writings, and of his *Crayfish*, perhaps the most perfect zoological treatise ever published, was first communicated to them. In one of the last communications I had with him, I asked his views as to the desirability of discontinuing the workmen's lectures in Jermyn Street, since the development of workmen's colleges and institutes was regarded by some as rendering their continuance unnecessary. He replied, almost with indignation, 'With our central situation and resources we ought to be in a position to give the workmen that which they cannot get elsewhere,' adding that he would deeply deplore any such discontinuance."

Huxley had no natural facility for speech. He tells us that at first he disliked it, and that he had

a firm conviction that he would break down every time he opened his mouth. Probably no lecturer was more successful or more familiar at the Royal Institution than Huxley, and yet he was nervous and unhappy every time he passed through the doors to face the tiers of faces that seem, so overwhelmingly, to press on the lecturer in that hall. On the last occasion when he was present at a lecture, although he was not going to speak, he told Sir James Dewar, that as he crossed the dais to a reserved seat, and glanced for a moment at the audience, he felt the familiar sinking sensation and desire to run away. The only two possible faults of a public speaker which he believed himself to be without, were "talking at random and indulging in rhetoric." With practice, he lost his earlier hesitancy, and before long became known as one of the finest speakers of his time. Certain natural gifts aided him; his well-set figure and strong features, of which the piercing eyes and firm, trap-like mouth were the most striking, riveted attention, while his voice had a wide range and was beautifully modulated. But it was above all things the matter and not the manner of his speech that commanded success. He cared little or nothing for the impression he might make—everything for the ideas which he wished to convey. He was concerned only to set forth these ideas in their clear and logical order, convinced in his own mind that, were the facts as he knew them placed before the minds of his hearers, only one possible result could follow. The facts had convinced him: they must equally convince any honest and intelligent person placed in possession of them. He had not the smallest intention of overbearing by authority or of swaying by skilfully aroused emotion. Such weapons of the orator seemed to him dishonest in the speaker and perilous to the audience. For him, speaking was merely a branch of scientific exposition; when emotion was to be roused or enthusiasm to be kindled the inspiration was to come from the facts and not from the orator. The arts he allowed himself were those common to all forms of exposi-

tion; he would explain a novel set of ideas by comparison with simpler ideas obvious to all his listeners; and he sought to arrest attention or to drive home a conclusion by some brilliant phrase that bit into the memory. These two arts, the art of the phrase-maker and the art of explaining by vivacious and simple comparison, he brought to a high level. The fundamental method of his exposition was simply that of comparative anatomy, the result of a habit of thinking which makes it impossible to have any set of ideas brought into the mind without an immediate, almost unconscious, overhauling of the memory for any other ideas at all congruous. In a strict scientific exposition Huxley would choose from the multitude of possible comparisons that most simple and most intelligible to his audience; when in a lighter vein, he gave play to a natural humour in his choice. Instances of his method of exposition by comparison abound in his published addresses. Let us take one or two. In the course of an address to a large mixed audience so early in his public career as 1854, in making plain to them the proposition, somewhat novel for those days, that the natural history sciences had an educational value, he explained that the faculties employed in that subject were simply those of the common sense of every-day life.

"The vast results obtained by Science are won by no mystical faculties, by no mental processes other than those which are practised by every one of us, in the humblest and meanest affairs of life. A detective policeman discovers a burglar from the marks made by his shoe, by a mental process identical with that by which Cuvier restored the extinct animals of Montmartre from fragments of their bones. Nor does that process of induction and deduction by which a lady, finding a stain of a peculiar kind on her dress, concludes that somebody has upset the inkstand thereon, differ in any way, in kind, from that by which Adams and Leverrier discovered a new planet."

In one of his addresses to working men on *Man's Place in Nature* he shewed that from time to time in the history of the world average persons of the

human race have accepted some kind of answer to the insoluble riddles of existence, but that from time to time the race has outgrown the current answers, ceasing to take comfort in them.

"In a well-worn metaphor a parallel is drawn between the life of man and the metamorphosis of a caterpillar into a butterfly; but the comparison may be more just as well as more novel, if for its former term we take the mental progress of the race. History shews that the human mind, fed by constant accessions of knowledge, periodically grows too large for its theorctical coverings, and bursts them asunder to appear in new habiliments, as the feeding and growing grub, at intervals, casts its too narrow skin and assumes another, itself but temporary. Truly, the imago state of man seems to be terribly distant, but every moult is a step gained, and of such there have been many."

As another instance, the following from his address on a "Liberal Education" may be taken. He had been discussing the intellectual advantage to be derived from classical studies, and had been comparing, to the disadvantage of the latter, the intellectual discipline which might be got from a study of fossils with the discipline claimed by the ordinary experts upon education to be the results of classical training. He wished to anticipate the obvious objection to his argument: that the subject-matter of palæontology had no direct bearing on human interests and emotions, while the classical authors were rich in the finest humanity.

"But it will be said that I forget the beauty and the human interest, which appertain to classical studies. To this I reply that it is only a very strong man who can appreciate the charms of landscape as he is toiling up a steep hill, along a bad road. What with short-windedness, stones, ruts, and a pervading sense of the wisdom of rest and be thankful, most of us have little enough sense of the beautiful under these circumstances. The ordinary schoolboy is precisely in this case. He finds Parnassus uncommonly steep, and there is no chance of his having much time or inclination to look about him till he gets

to the top. And nine times out of ten he does not get to the top."

Another example comes from an after-dinner speech at a much later period of his life. The occasion was a complimentary dinner to the editor of the English scientific periodical *Nature*, which had been for long the leading semi-popular journal of English science. Huxley, in proposing the health of the editor, declared that he did not quite know how to say what he wanted to say, but that he would explain by a story.

"A poor woman," he said, "was brought into one of our hospitals in a shockingly battered condition. When her wounds had been cleaned and sewn, and when the care of the surgeons had restored her to comparative comfort, someone said to her, 'I am afraid your husband has been knocking you about.' 'What!' she said, 'my Jim bash me? no it worn't him; he's always been more like a friend to me than a husband.' That," went on Huxley, "is what I wish to say about our guest of to-night. In all our intercourse with him he has been more like a friend to us than an editor."

At another dinner, late in life, when he was responding for "Science" he related a strange dream. He thought that he had just died, and had come to consciousness, in a vast and luxurious subterranean hall, fitted up rather like the frigidarium of a luxurious Turkish bath. Looking about him, he saw some attendants in livery, and to his surprise saw that the nearest servitor, whose back was turned, had a forked tail protruding between the buttons of his braided coat. Going up to him, Huxley gave the tail a smart tug, and the waiter turned politely and said, "Yes, sir, what can I do for you, Professor?" "Well," said Huxley, "could you get me a drink?—perhaps iced," he added a little doubtfully, for the room was a little warm. "Certainly," said the waiter, and presently returned with what had been selected. Huxley sipped it luxuriously, and remarked, "I suppose I am not wrong about where I have come to?"

"No, Professor, this *is* hell." "But surely there has been a good deal of change? this doesn't at all agree with what we used to be told of the place." "Why, no, sir," said the devil, "hell isn't what it used to be. A great many of you scientific gents have been coming here recently, and they have turned the whole place upside down."

It is impossible to make a real distinction between the essays and the addresses of Huxley. Some of the most important of his addresses, as for instance his Romanes lecture on "Evolution and Ethics," were written and printed before he delivered them; most were carefully prepared, and revised and printed after delivery. It is therefore not remarkable to find a close resemblance in matter and manner between what was originally spoken and what was published without a *vivâ voce* delivery. Everything that may be said of the one set applies with an equal fitness to the other set. Huxley has often been described as one of the great masters of English, and although an examination of this opinion involves discussion of the elusive quality termed "style," it is necessary to attempt it.

In that totality which consists of an essay or of a printed address, and of which we are, most of us, ready to discuss the style, there are at least three separable elements, each contributing after its kind to the effect on our minds. When the general effect is to throw us into a state of pleasure, it is our habit to qualify the style with an adjective of praise, selecting the adjective according to the degree of restraint or of enthusiasm with which we are accustomed to express our emotions; when the general effect is to throw us into a condition of boredom or of distaste, we make a corresponding choice of appropriate adjectives. When we wish to be specially critical we pass a little way beyond an empirical judgment by pleasure or annoyance and take into account the degree of harmony between matter and manner. In such a frame of mind we discount the pleasure obtained from verbal quips, if these occur in a grave exposition, or that received from solemn and stately harmonies of

language if these be employed on insignificant trifles. In a condition of unusual critical exaltation we may even admit an excellence of language and phrasing though these have as their contents ideas which we dislike, or press towards conclusions from which we dissent. But if we desire to make an exact appreciation of literary style, it is requisite to examine separately the three elements which contribute to the effect produced on us by any written work. These three elements are the words or raw materials employed, the building of words into sentences and of sentences into paragraphs, which may be designated as the architectural work, and, finally, the ideas conveyed, that is to say, the actual context of the writing.

Huxley was a wide and omnivorous reader, and so had an unusually large fund of words at his disposal. His writings abound with quotations and allusions taken from the best English authors, and he had a profound belief in the advantage to be gained from the reading of English. "If a man," he wrote, "cannot get literary culture out of his Bible, and Chaucer, and Shakespeare, and Milton, and Hobbes, and Bishop Berkeley, to mention only a few of our illustrious writers—I say, if he cannot get it out of these writers, he cannot get it out of anything." He had at least a fair knowledge of Greek acquired in middle age, and a very wide acquaintance with Greek phrasing and Greek ideas derived from a study of Greek authors in English versions. He had an unusual knowledge of Latin, both of the classical writers and of the early Church fathers and mediæval writers on science and metaphysics. French and German, the two foreign languages which are a necessary part of the mental equipment of an English-speaking man of science, were familiar to him. Finally, he had of necessity the wide and varied vocabulary of the natural and technical sciences at his disposal. From these varied sources, Huxley had a fund of words, a store of the raw material for expressing ideas, very much greater and more varied than that in the possession of most writers. You will find in his writings

abundant and omnipresent evidence of the enormous wealth of verbal material ready for the ideas he wished to set forth: a Greek phrase, a German phrase, a Latin or French phrase, or a group of words borrowed from one of our own great writers always seemed to await his wish. General Booth's scheme for elevating the masses by cymbals and dogma was "corybantic Christianity"; to explain what he thought was the Catholic attitude to the doctrine of evolution, he said it would have been called *damnabilis* by Father Suarez, and that he would have meant "not that it was to be damned, but that it was an active principle capable of damning." Huxley was like a builder who did not limit himself while he was constructing a house to the ordinary materials from the most convenient local quarry, but who had collected from all the quarries and brickfields of the world, and had brought to his heaps curiously wrought stones taken from a thousand old buildings. The swift choice from such a varied material gave an ease and appearance of natural growth to his work; it produced many surprising and delightful combinations, and it never sacrificed convenience of expression to exigencies of the materials for expression. On the other hand, Huxley lacked the sedulous concern for words themselves as things valuable and delightful; the delight of the craftsman in his tools; the dainty and respectful tribute paid to the words themselves; in fine, he took little pleasure in words themselves and used them as counters rather than as coins. Careful examination will make it plain that the pleasure to be got from Huxley's style is not due in any large measure to his choice and handling of words. There is no evidence that he deliberately and fastidiously preferred one word to another, that he took delight in the savour of individual words, in the placing of plain words in a context to make them sparkle, in the avoidance of some, in the deliberate preference of other words—in fact, in all the conscious tricks and graces that distinguish the lover of words from their mere user.

A close examination discovers a similar absence

from Huxley's work of the second contributory to the total effect produced by written words. Anything that may be said about absence of artistry in the use of words, may be said as to absence of artistry in building of the words into sentences, of the sentences into paragraphs and pages. In the first place, actual infelicities of sentence-building are frequent. Clause is piled on clause, qualifying phrases are interpolated, the easy devices of dashes and repetitions are employed wherever convenience suggests them. It is striking to find how infrequent is the occurrence of passages marked in any way by sonorous rhythm or by the charm of a measured proportion. The purple passages themselves, those which linger in the memory and to which the reader turns back, linger by their sense and not by their sound. For indeed the truth of the matter is that Huxley's style was a style of ideas and not of words and sentences. The more closely you analyse his pages the more certainly you find that the secret of the effect produced on you lies in the gradual development of the precise and logical ideas he wished to convey, in the brilliant accumulation of argument upon argument, in the logical subordination of details to the whole, in fact, in the arts of the convinced, positive, and logical thinker, who knew exactly what he meant you to know and who set about telling you it with the least possible concern for the words he used or for the sentences into which he formed his words. The ideas and their ordering are the root and the branches, the beginning and the end of his style. To put it in another way: it would be extremely easy to translate any of Huxley's writings into French or German, and they would lose little of the personal flavour of their author. The present writer has just been reading French translations of Huxley's *Physiography* and *Crayfish*, made at different times by different translators. At first reading it seems almost miraculous how identically the effect produced by the original is reproduced by the French rendering, but the secret is really no secret at all. Huxley produced his effects by the ordering of his

ideas and not by the ordering of his words. From the technical point of view of literary craftsmanship, he cannot be assigned a high place; he is one of our great English writers, but he is not a great writer of English.

CHAPTER XIII

THE OPPONENT OF MATERIALISM

THE prosecution of independent thinking in any branch of knowledge leads to the ultimate problems of philosophy. The mathematician cannot ponder over the meaning of his figures, the chemist that of his reactions, the biologist that of his tissues and cells, the psychologist that of sensations and conceptions, without being tempted from the comparatively secure ground of observations and their arrangement into the perilous regions of metaphysics. Most scientific men return quickly, repelled and perhaps a little scared by the baffling confusion of that windy region of thought where no rules of logic seem incontrovertible, no conclusions tenable, and no discussions profitable. Huxley, however, not only entered into metaphysical questions with enthusiasm, but gave much time to the study of some of the great metaphysical writers. His views are to be found scattered through most of his scientific writings, but are specially set forth in a volume on *Hume,* which he wrote for Lord Morley's series, *English Men of Letters,* and in essays on Berkeley and on Descartes, all of which are republished in the *Collected Essays.* He contrived to preserve, in the most abstrusely philosophical of these writings, a simplicity and clarity which, although they have not commended him to professional metaphysicians, make his attitude to the problems of metaphysics extremely intelligible. The greatest barrier and cause of confusion to the novice in metaphysics are that the writings of most of the authorities are overburdened by their great

knowledge of the history of philosophy. Huxley, in a characteristic piece of "parting advice" in the preface to his work on Hume attacked this confusion between the history of a subject and the subject itself.

"If it is your desire," he wrote, "to discourse fluently and learnedly about philosophical questions, begin with the Ionians and work steadily through to the latest new speculative treatise. If you have a good memory and a fair knowledge of Greek, Latin, French, and German, three or four years spent in this way should enable you to attain your object. If, on the contrary, you are animated by the much rarer desire for real knowledge; if you want to get a clear conception of the deepest problems set before the intellect of man, there is no need, so far as I can see, for you to go beyond the limits of the English tongue. Indeed, if you are pressed for time, three English authors will suffice, namely, Berkeley, Hume, and Hobbes."

The first and perhaps the greatest problem in metaphysics can be put concisely. What is the reality behind the apparent universe of matter and mind we see around us? Or, rather, what is reality, and what do we know of it? To the uninitiated in philosophy it seems sufficiently plain that there are two entities, body and soul in man, matter and mind in the whole universe; and various types of intelligent dogmatists, ranging from the sturdy but stupid shrewdness of Dr. Johnson to the agile casuistry of Catholic metaphysicians, have supported this simple verdict of "common sense." Trouble begins, however, with any attempt to analyse the relations between what we call "matter" and what we call "mind." It appears, for instance, that what we call matter we only know in terms of mind. In an essay on Descartes's *Discourse on Method*, Huxley explains this by simple examples.

"I take up a marble and I find it to be a red, round, hard, single body. We call the redness, the roundness, the hardness and the singleness, 'qualities' of the marble; and it sounds, at first, the height of absurdity to say that all these qualities are modes of

our own consciousness, which cannot even be conceived to exist in the marble. But consider the redness, to begin with. How does the sensation of redness arise? The waves of a certain very attenuated matter, the particles of which are vibrating with vast rapidity, but with very different velocities, strike upon the marble, and those which vibrate with one particular velocity are thrown off from its surface in all directions. The optical apparatus of the eye gathers some of these together, and gives them such a course that they impinge upon the surface of the retina, which is a singularly delicate apparatus connected with the terminations of the fibres of the optic nerve. The impulses of the attenuated matter, or ether, affect this apparatus and the fibres of the optic nerve in a certain way; and the change in the fibres of the optic nerve produces yet other changes in the brain; and these, in some fashion unknown to us, give rise to the feeling, or consciousness, of redness. If the marble could remain unchanged, and either the vibrations of the ether, or the nature of the retina, could be altered, the marble would seem not red, but some other colour. There are many people who are what are called colour-blind, being unable to distinguish one colour from another. Such an one might declare our marble to be green; and he would be quite as right in saying that it is green as we are in declaring it to be red. But then, as the marble itself cannot be both green and red, at the same time, this shews that the quality redness must be in our consciousness and not in the marble."

In similar fashion he shewed that the hardness, roundness, and even the singleness of the marble were, so far as we know, states of our consciousness and not in the marble. The argument is capable of application to all that we call matter, and it thus appears that what we know of matter is simply a series of states of our consciousness, or mind. In similar fashion, it turns out that what we call mind is, so far as practical experience goes, always associated with and dependent on what we call matter. We have no knowledge of thinking without a brain, or of consciousness without a body. Alterations and changes in matter, as for instance in the tissues and nutrition of the body, are, so far as our experience goes, inseparably associated with

mental operations. In the animal kingdom we see the development of the mind creeping slowly after the development of the material nervous system, until, in man, the most complex mind and most complex consciousness of which we have knowledge accompany the most complex body and brain.

Two great rival solutions to this fundamental problem are Materialism and Idealism. Materialism supposes that what we call matter is the real substance of the universe, and that mind is merely one of the forms of its activity. The advance of physical science has done much to make the materialistic hypothesis more plausible. When matter was believed to be inert, the mere vehicle or theatre of forces, materialism was a crude and unsatisfying position. But now that science has shewn all that we call matter—the most solid metals and the most attenuated vapours, the most stable and resisting inorganic bodies, and the unstable tissues of living bodies—to be alike in restless, orderly motion, to be, in fact, motion itself and not the things moved, to be changeable but indestructible, passing through phases but eternal, there seems less difficulty in assuming it to be the ultimate reality, and mind and consciousness to be its most highly specialised qualities. Huxley, while stating this view plainly enough, refused to accept it as a legitimate conclusion from the facts.

"For anything that may be proved to the contrary, there may be a real something which is the cause of all our impressions; that sensations, though not likenesses, are symbols of that something; and that the part of that something, which we call the nervous system, is an apparatus for supplying us with a sort of algebra of fact, based on these symbols. A brain may be the machinery by which the material universe becomes conscious of itself. But it is important to notice that, even if this conception of the universe and of the relation of consciousness to its other components should be true, we should, nevertheless, be still bound by the limits of thought, still unable to refute the arguments of pure idealism. The more completely the materialistic position is admitted, the easier it is to shew that the idealistic

position is unassailable, if the idealist confines himself within the limits of positive knowledge."

However we attempt to form what philosophers call " ejects," to imagine that what is really in our consciousness is really the world outside ourselves, these ejects remain mere phenomena of our minds. Matter itself and its changes may, in the long run, be only modes of motion, but " our knowledge of motion is nothing but that of a change in the place and order of our sensations; just as our knowledge of matter is restricted to those feelings of which we assume it to be the cause." Huxley's exact position in regard to materialism is most plain in his expositions of the writings of Berkeley, with whom began in England the greatest movement towards an idealistic philosophy.

" Berkeley faced the problem boldly. He said to the materialists: 'You tell me that all the phenomena of nature are resolvable into matter and its affections. I assent to your statement, and now I put to you the further question, What is matter? In answering this question you shall be bound by your own conditions; and I demand, in the terms of the Cartesian axiom, that you in turn give your assent only to such conclusions as are perfectly clear and obvious.'"

Huxley then stated the general lines of the arguments by which Berkeley arrived at the apparently paradoxical conclusion that " all the choir of heaven and furniture of the earth—in a word, all those bodies which compose the mighty frame of the world," have an existence only so far as they are in a perceiving mind. And he proceeds at length to explain the immense importance of the truths underlying Berkeley's position.

" The key to all philosophy lies in the clear apprehension of Berkeley's problem—which is neither more nor less than one of the shapes of the greatest of all questions, 'What are the limits of our faculties?' And it is worth any amount of trouble to comprehend the exact nature of the argument by which Berkeley

arrived at his results, and to know by one's own knowledge the great truth which he discovered—that the honest and rigorous following up of the argument which leads us to materialism inevitably carries us beyond it."

Huxley, however, while he opposed a materialistic explanation of the universe with the strength of exposition and acute reasoning at his disposal, did not pass directly into the other camp and become a pure idealist.

"Granting the premisses," he wrote, "I do not see any escape from Berkeley's conclusion, that the substance of matter is a metaphysical unknown quantity, of the existence of which there is no proof. What Berkeley does not seem to have so clearly perceived is that the non-existence of a substance of mind is equally arguable; and that the result of the impartial application of his reasonings is the reduction of the all to co-existences and sequences of phenomena, beneath and beyond which there is nothing cognoscible."

Hume had written: "What we call a mind is nothing but a heap or collection of different perceptions, united together by certain relations, and supposed, though falsely, to be endowed with a perfect simplicity and identity." Here was mind rejected for the same negative reasons as matter, and Huxley was as ready to point out that while we can know nothing of the

"substance of the thinking thing, we go beyond legitimate reasoning if we therefore deny its existence." . . . "Hume may be right or wrong, but the most he or anyone else can prove in favour of his conclusions is, that we know nothing more of the mind than that it is a series of perceptions. Whether there is something in the mind that lies beyond the reach of observation, or whether perceptions themselves are the products of something which can be observed and which is not mind, are questions which can in no wise be settled by direct observation."

In another passage he writes:

"To sum up. If the materialist affirms that the universe and all its phenomena are resolvable into matter and motion, Berkeley replies, True; but what you call matter and motion are known to us only as forms of consciousness; their being is to be conceived or known; and the existence of a state of consciousness, apart from a thinking mind, is a contradiction in terms. I conceive that this reasoning is irrefragable. And therefore, if I were obliged to choose between absolute materialism and absolute idealism, I should feel compelled to accept the latter alternative. Indeed, upon this point Locke does, practically, go as far in the direction of idealism as Berkeley, when he admits that the 'simple ideas which we receive from sensation and reflection are the boundaries of our thoughts, beyond which the mind, whatever efforts it would make, is not able to advance one jot.'"

Locke went further, and Huxley agreed with him. He declared that the mind cannot "make any discoveries when it would pry into the nature and hidden cause of these ideas." We must, in fact, definitely reject matter from any claim to be the absolute reality of the universe, for it becomes very plain that what we call matter we know merely as affections of our own consciousness. In a sense, then, so far as it is opposed to materialism, idealism, according to Huxley, must be the philosophical position of a scientific man. But this idealism is not the absolute idealism of Berkeley, as we have no logical right to deny or to affirm the existence of absolute matter or of absolute mind. The real truth of the philosophy of science lies in a separation between metaphysical theory and actual pursuits. In ultimate philosophical theory it is impossible to rest content with a plain natural conception of the universe. When any conception of matter, or of its affections. is pushed as far as analysis can take us, what we know resolves itself into affections of mind, into what without metaphysical finesse may be called ideas. But this empirical idealism must be taken positively as being a natural limit of our knowledge, and must carry with it neither an undue exaltation of mind nor an undue depreciation of matter.

"The Platonic philosophy is probably the grandest example of the unscientific use of the imagination extant; and it would be hard to estimate the amount of detriment to clear thinking affected, directly and indirectly, by the theory of ideas, on the one hand, and by the unfortunate doctrine of the baseness of matter, on the other."

Materialism was dismissed by Huxley as being an inadequate explanation of the universe, and as being based on a logical delusion. There remains, however, a practical application of the word in which the conceptions it involves are almost an inevitable part of science, and which was strenuously urged by Huxley. In the earlier days of the world and of science almost all the phenomena of nature were regarded as random or wilful displays of living intelligence. The earth itself and the sun, the moon, and the stars were endowed with life; legions of unseen intelligences ruled the operations of nature, and although these might be bribed or threatened, pleased or made angry, their actions were regarded as beyond prediction or control. The procession of the seasons, the routine of day and night, the placid appeasement of the rains, the devastating roar of storms, the shining of the rainbow, the bubbling of springs, the terrors of famine and pestilence; all these—the varying environment which makes or mars human life—were attributed to capricious personalities. The whole progress of physical science has been attended with a gradual elimination of these supernatural agencies and with a continual replacement of them by conceptions of physical sequence.

"In singular contrast with natural knowledge, the acquaintance of mankind with the supernatural appears the more exact, and the influence of supernatural doctrine on conduct the greater, the further we go back in time and the lower the stage of civilisation submitted to investigation. Historically, indeed, there would seem to be an inverse relation between supernatural and natural knowledge. As the latter has widened, gained in precision and trustworthiness, so has the former shrunk, grown vague and questionable; as the one has more and more

filled the sphere of action, so has the other retreated into the region of meditation, or vanished behind the screen of mere verbal recognition. Whether this difference of the fortunes of Naturalism and Supernaturalism is an indication of the progress, or of the regress of humanity, of a fall from or an advance towards the higher life, is a matter of opinion. The point to which I wish to direct attention is that the difference exists and is making itself felt. Men are growing seriously alive to the fact that the historical evolution of humanity, which is generally, and I venture to think, not unreasonably, regarded as progress, has been and is being accompanied by a co-ordinate elimination of the supernatural from its originally large occupation of men's thought."

Every stage in this long process, every new attempt to place physical phenomena in a chain of direct causation have been denounced as dangerous and degrading materialism, and in this sense Huxley was not only an adherent but one of the foremost champions of materialism. As everyone knows, some of the greatest advances in this process of co-ordinating physical phenomena were made during Huxley's life; and his vigorous onslaughts on those who tried to thwart attempts at material explanations in favour of unknown agencies made him specially open to abusive criticism. The battle was almost invariably between those who had not special knowledge and those in possession of it, and it occurred in practically the whole field of science, but particularly in the biological sciences. A single example will serve to shew what is meant by materialism in this sense and the attitude of Huxley to it. The study of the human mind has attracted the attention of thinkers almost since the beginning of philosophy, but until this century, with a few crude exceptions, it has been conducted entirely apart from anatomy and physiology. Advances in these physical sciences, however, have changed that, and the modern psychologist has to begin by being a physiologist and anatomist.

"Surely no one who is cognisant of the facts of the case, nowadays, doubts that the roots of psy-

chology lie in the physiology of the nervous system. What we call the operations of the mind are the functions of the brain, and the materials of consciousness are products of cerebral activity. Cabanis may have made use of crude and misleading phraseology when he said that the brain secretes thought as the liver secretes bile; but the conception which that much-abused phrase embodies is, nevertheless, far more consistent with fact than the popular notion that the mind is a metaphysical entity seated in the head, but as independent of the brain as a telegraph operator is of his instrument. It is hardly necessary to point out that the doctrine just laid down is what is commonly called materialism. I am not sure that the adjective 'crass,' which appears to have a special charm for rhetorical sciolists, would not be applied to it. But it is, nevertheless, true that the doctrine contains nothing inconsistent with the purest idealism."

The whole doctrine of evolution is similarly a materialistic account of natural phenomena, in the popular and not the philosophical meaning of the term. But even within this popular meaning, it is necessary to have an exact conception of the limits within which Huxley was materialistic. Take for instance the question of the origin of life. It would be one of the greatest achievements of physical science could it shew that life was not inco-ordinate with non-living physical phenomena, but was a special case of them. Huxley knew that this advance had not yet been made.

"It may be that, by-and-by, philosophers will discover some higher laws of which the facts of life are particular cases—very possibly they will find out some bond between physico-chemical phenomena on the one hand, and vital phenomena on the other. At present, however, we assuredly know of none; and I think we shall exercise a wise humility in confessing that, for us at least, this successive assumption of different states (external condition remaining the same)—this spontaneity of action—if I may use a term which implies more than I would be answerable for—which constitutes so vast and plain a practical distinction between living bodies and those which do not live, is an ultimate fact, indicating as such, the

existence of a broad line of demarcation between the subject matter of biological and of all other science."

In another passage he wrote:

"Looking back through the prodigious vista of the past I find no record of the commencement of life, and therefore I am devoid of any means of forming a definite conclusion as to the conditions of its appearance. Belief, in the scientific sense of the word, is a serious matter, and needs strong foundations. To say, therefore, in the admitted absence of evidence, that I have any belief as to the mode in which the existing forms of life have originated, would be using words in a wrong sense. But expectation is permissible where belief is not; and if it were given me to look beyond the abyss of geologically recorded time to the still more remote period when the earth was passing through physical and chemical conditions which it can no more see again than a man can recall his infancy, I should expect to be a witness of the evolution of living protoplasm from non-living matter. I should expect to see it appear under forms of great simplicity, endowed, like existing fungi, with the power of determining the formation of new protoplasm from such matters as ammonium carbonates, oxalates, and tartrates, alkaline and earthy phosphates, and water, without the aid of light. That is the expectation to which analogical reasoning leads me, but I beg you once more to recollect that I have no right to call my opinion anything but an act of philosophical faith."

Since these words were written the reasons for Huxley's "philosophic faith" have been strengthened by later discoveries, and perhaps a majority of biologists would take the view that except for practical purposes there is no sound reason for placing living and inorganic aggregations of matter in totally different categories. But even if the main outline of the theory of evolution were proved beyond the possibility of doubt, if we could trace existing plants and animals backwards with the accuracy of a genealogist and find that they had been developed, under purely physical "laws" from a few simple forms, and if we could understand exactly how these few simple forms of living

matter took origin from non-living matter, we would not, if we followed Huxley, be able to rest in a purely materialistic position. As he, in different words, repeatedly said :

"It is very desirable to remember that evolution is not an explanation of the cosmos, but merely a generalised statement of the method and results of that process. And, further, that, if there is any proof that the cosmic process was set going by any agent, then that agent will be the creator of it and of all its products, although supernatural intervention may remain strictly excluded from its further course."

The doctrine of evolution was, for him, no attempt to reinstate the "old Pagan goddess, Chance." Darwin had more than once explained, and Huxley again and again had called attention to the explanation, that when words like "chance" and "spontaneous" were used, no more was intended to be implied than an ignorance of the causes. In the true sense of the word "chance" did not exist for Huxley and Darwin. So far as all scientific and common experience goes, every event is connected with foregoing events in an orderly and inevitable chain of sequences—a chain that could have been predicted or predetermined by any sufficient intelligence. Moreover, Huxley did not believe that Darwin's views, rightly interpreted, "abolished teleology and eviscerated the argument from design." They only abolished that crude expression of teleology which supposed all structures among animals and plants to have been created in their present forms for their present purposes. Under the stimulus given to biology by the doctrine of evolution the science of life has advanced beyond conceptions so crudely mechanical, we know that behind each existing structure there is a long history of change; of change not only in form and appearance, but also in function. In the development of living organisms to-day, as they grow up into tree or animal from seed or egg, we can trace the record of these changes of form; in some cases we can follow the actual change of function. But

in a wider sense there is no incongruity between evolution and teleology.

"There is a wider teleology," Huxley wrote, "which is not touched by the doctrine of evolution, but is actually based on the fundamental proposition of evolution. This proposition is that the whole world, living and not living, is the result of the mutual interaction, according to definite laws, of the forces possessed by the molecules of which the primitive nebulosity of the universe was composed. That acute champion of teleology, Paley, saw no difficulty in admitting that the 'production of things' may be the result of mechanical dispositions fixed beforehand by intelligent appointment and kept in action by a power at the centre."

CHAPTER XIV

FREEDOM OF THOUGHT

IN the practice of modern law-courts, a witness rarely is allowed to offer as evidence any statement for which he himself is not the direct authority. What he himself saw or heard or did with regard to the matter at issue—these, and not what others told him they had seen or heard or done, are the limits within which he is allowed to be a competent witness. In the business of life we have to act differently. A large proportion of our opinions, beliefs, and reasons for conduct must come to us on the authority of others. We have no direct experience of the past; of the present we can see little and only the little immediately surrounding us. In a multitude of affairs we have to act on authority, to accept from books or from persons what we have not ourselves the opportunity of knowing. It would seem, then, to be a primary duty to learn to distinguish in our minds those matters which we know directly from those matters which we have accepted on trust; and, secondly, to learn and to apply the best modes of choosing the good and of rejecting the bad authorities. The work of the scientific man is a lifelong exercise of these primary duties. From the first moment he begins to observe living things or to dissect their dead frameworks, to mix chemical substances, to make experiments with magnets and wires, he begins to build, and as long as he continues to work he continues to build for himself a body of first-hand knowledge. But, however he work arduously or through long years, he can visit only

the smallest portion of the field of nature in which he is working. It is necessary for him to employ the work of others, submitting, from time to time, such accepted work to the tests suggested by his own observations. He learns to regard in a different light all knowledge taken on the authority of others; to distrust it a little until he has learned to weigh its general credibility by his own standards, and its particular credibility by subjecting portions of it to his own tests; to distrust it still more when even small portions fail to answer his tests, and to reject it altogether when the percentage of detected error is large. He learns, in fact, what Huxley called the duty of doubt.

This duty has not been universally accepted. In the history of Christian civilisation (and a parallel series of events might be portrayed from the history of other civilisations), many great institutions and very many great and good men have condemned and feared the habit and attitude of doubt in all its forms. Certain doctrines believed to be of supreme importance to mankind were held to rest on authority independent of, and perhaps not susceptible to, the kind of testing employed in science. Around these doctrines there grew, in time, a body of traditions, customs, new dogmas, and fantasies; and the duty of belief in the first was extended to cover the whole system, the central jewel as well as the accretions and encrustations of time. The domain of religious authority was extended to the whole field of human thought and of human action, and the more unreasonable the dominion became, the more strenuously was the duty of belief urged. The Protestant Reformation was one of the great stages in the conflict for freedom against the universal tyranny that had arisen, but the reformers very naturally retained a considerable portion of the bias against which they had fought. In Protestant countries, in the first half of this century, the duty of belief in the Protestant doctrines, traditions, philosophy, history, and attitude to science reigned supreme, and all weapons, from legitimate argument to abusive

invective and social ostracism, were employed against those who acted in accordance with the duty of doubt. Allegations of "unsoundness" or of "free thinking" became barriers to success in life, and those against whom they were made were lowered in the esteem of their fellows. Perhaps there is no more ridiculously complete evidence for the strength of the dogmatic habit, than that the words "free thinker" and "free thought" have acquired a flavour of contumely.

At the present time, when the advance of science and of civilisation has almost won the battle for freedom of thought, it is difficult to realise the strength of the forces against which Huxley and many others had to fight. Huxley himself said with perfect justice: "I hardly know of a great physical truth whose universal reception has not been preceded by an epoch in which most estimable persons have maintained that the phenomena investigated were directly dependent on the Divine Will, and that the attempt to investigate them was not only futile but blasphemous." As a particular instance of this he cited some episodes in the history of geological science.

"At the present time, it is difficult to persuade serious scientific enquirers to occupy themselves, in any way, with the Noachian Deluge. They look at you with a smile and a shrug, and say they have more important matters to attend to than mere antiquarianism. But it was not so in my youth. At that time geologists and biologists could hardly follow to the end any path of enquiry without finding the way blocked by Noah and his ark, or by the first chapter of Genesis; and it was a serious matter, in this country at any rate, for a man to be suspected of doubting the literal truth of the Diluvial or any other Pentateuchal history. The fiftieth anniversary of the foundation of the Geological Club (in 1824) was, if I remember rightly, the last occasion on which the late Sir Charles Lyell spoke to even so small a public as the members of that body. Our veteran leader lighted up once more; and, referring to the difficulties which beset his early efforts to create a rational science of geology, spoke, with his wonted clearness and vigour, of the social ostracism which

pursued him after the publication of the *Principles of Geology*, in 1830, on account of the obvious tendency of that noble work to discredit the Pentateuchal accounts of the Creation and the Deluge. If my younger contemporaries find this hard to believe, I may refer them to a grave book *On the Doctrine of the Deluge*, published eight years later, and dedicated by the author to his father, the then Archbishop of York. The first chapter refers to the treatment of the 'Mosaic Deluge,' by Dr. Buckland and Mr. Lyell, in the following terms: 'Their respect for revealed religion has prevented them from arraying themselves openly against the Scriptural account of it—much less do they deny its truth—but they are in a great hurry to escape from the consideration of it, and evidently concur in the opinion of Linnæus, that no proofs whatever of the Deluge are to be discovered in the structure of the earth.' And after an attempt to reply to some of Lyell's arguments, which it would be cruel to reproduce, the writer continues:—'When, therefore, upon such slender grounds, it is determined, in answer to those who insist on its universality, that the Mosaic Deluge must be considered a preternatural event, far beyond the reach of philosophical enquiry; not only as to the causes employed to produce it, but as to the effects most likely to result from it; that determination wears an aspect of scepticism, which, however much soever it may be unintentional in the mind of the writer, yet cannot but produce an evil impression on those who are already predisposed to carp and cavil at the evidence of Revelation.'"

The great evil of authority was its tendency to erect itself into some form of infallibility of universal application. When, for a time, the geological victory was won, and the supporters of authority had comforted themselves with reconciliations, there arose the much greater and more serious opposition between authority and the conceptions involved in evolution. Huxley, as we have seen in an earlier chapter, found that all the old weapons of authority were resumed with a renewed assurance, and his advocacy of the duty of doubt became not merely the defence of a great principle but a means of self-defence. The conception of infallible authority had been transferred by Protestants from

the Church to the Bible, and against this Huxley strove with all his might. It is convenient to reserve a full treatment of Huxley's attitude to the Bible for a separate chapter, but at this point a quotation will shew his general view.

"The truth is that the pretension to infallibility, by whomsoever made, has done endless mischief; with impartial malignity it has proved a curse, alike to those who have made it and those who have accepted it; and its most baneful shape is book infallibility. For sacerdotal corporations and schools of philosophy are able, under due compulsion of opinion, to retreat from positions that have become untenable; while the dead hand of a book sets and stiffens, amidst texts and formulæ, until it becomes a mere petrifaction, fit only for that function of stumbling-block, which it so admirably performs. Wherever bibliolatry has prevailed, bigotry and cruelty have accompanied it. It lies at the root of the deep-seated, sometimes disguised, but never absent, antagonism of all varieties of ecclesiasticism to the freedom of thought and to the spirit of scientific investigation."

Moreover, Presbyter is but Priest writ large, and the Protestant clergy were the leaders in denunciation of every person and every branch of investigation or of thought in any way connected with evolution. Huxley was no respecter of persons, and, following the example of Darwin, he was ready to study carefully any arguments for or against any scientific doctrines by whomsoever or howsoever brought forward. The right of criticism and duty of doubt, which he insisted on for himself, he was extremely willing to extend to others, and he was on terms of intimate friendship with some of his most distinguished clerical opponents. But to an extent which it is almost impossible now to realise, the clergy generally abused their position and authority, and demanded or assumed a right to give authoritative opinions on questions which did not come within their domain. It was the old attempt of the Church to make its authority felt in all departments of thought and of action, and the attempt was made in the traditional fashion.

Questions of fact were associated with questions of morality, and those who held one view as to the meaning and implication of certain facts were denounced as wicked. Huxley at once carried the war into the enemy's own country:

"And, seeing how large a share of this clamour is raised by the clergy of one denomination or another, may I say, in conclusion, that it really would be well if ecclesiastical persons would reflect that ordination, whatever deep-seated graces it may confer, has never been observed to be followed by any visible increase in the learning or the logic of its subject. Making a man a Bishop, or entrusting him with the office of ministering to even the largest of Presbyterian congregations, or setting him up to lecture to a church congress, really does not in the smallest degree augment such title to respect as his opinions may intrinsically possess. And when such a man presumes, on an authority which was conferred on him for other purposes, to sit in judgment on matters his incompetence to deal with which is patent, it is permissible to ignore his sacerdotal pretensions, and to tell him, as one would tell a mere, common, unconsecrated layman: that it is not necessary for any man to occupy himself with problems of this kind unless he so choose; life is filled full enough with the performance of its ordinary and obvious duties. But that, if a man elect to become a judge of these grave questions; still more if he assume the responsibility of attaching praise or blame to his fellow-men for the conclusions at which they arrive touching them, he will commit a sin more grievous than most breaches of the decalogue, unless he avoid a lazy reliance upon the information that is gathered by prejudice and filtered through passion, unless he go back to the prime sources of knowledge—the facts of Nature, and the thoughts of those wise men who for generations past have been her best interpreters."

In the campaign for absolute freedom of thought, for the duty of not believing anything except on sufficient evidence, Huxley was frequently met by an argument of superficial strength, and which no doubt was in the minds of many of his clerical opponents. In the minds of a majority of people, it was said, and particularly of slightly educated

people, the reasons for right conduct and the distinctions between right and wrong are firmly associated with the Bible and with religion. If you allow doubts as to the absolute veracity of the Bible, or as to the supernatural origin of religion to reach such persons, you run a grave risk that they will reflect the uncertainty on the canons of morality. In taking from them what you believe to be false, inevitably you will unsettle their ideas on moral questions although you might be in full agreement as to these moral questions. Huxley refused to accept the asserted association between morality and particular metaphysical or religious doctrines.

"Many ingenious persons now appear to consider that the incompatibility of pantheism, of materialism, and of any doubt about the immortality of the soul, with religion and morality is to be held as an axiomatic truth. I confess that I have a certain difficulty in accepting this dogma. For the Stoics were notoriously materialists and pantheists of the most extreme character; and while no strict Stoic believed in the eternal duration of the individual soul, some even denied its persistence after death. Yet it is equally certain, that, of all gentile philosophies, Stoicism exhibits the highest ethical development, is animated by the most religious spirit, and has exerted the profoundest influence upon the moral and religious development not merely of the best men among the Romans, but among the moderns down to our own day."

He held the view now generally taken by students of the history of man, that standards of conduct and religious beliefs arose in separate ways and developed independently, and that it was only comparatively recently that "religion took morality under its protection." But he met the argument in a still more direct fashion by rejecting entirely the possibility or advisability of founding any system of ethics upon a false basis.

"It is very clear to me," he wrote, "that, as Beelzebub is not to be cast out by Beelzebub, so morality is not to be established by immorality. It is, we are told, the special peculiarity of the devil that he was

a liar from the beginning. If we set out in life with pretending to know that which we do not know; with professing to accept for proof evidence which we are well aware is inadequate; with wilfully shutting our eyes and our ears to facts which militate against this or that comfortable hypothesis; we are assuredly doing our best to deserve the same character."

Freedom of thought meant for Huxley all that is best in liberalism applied to life. In an essay on Joseph Priestley, he described the condition of affairs in England last century, when scientific investigation and all forms of independent thinking laboured under the most heavy restrictions that could be imposed by dominant ecclesiastical and civil prejudice. He pointed out the astounding changes between these times and the times of to-day.

"If we ask," he wrote, "what is the deeper meaning of all these vast changes, there can be but one reply. They mean that reason has asserted and exercised her primacy over all the provinces of human activity; that ecclesiastical authority has been relegated to its proper place; that the good of the governed has been finally recognised as the end of government, and the complete responsibility of governors to the people as its means; and that the dependence of natural phenomena in general on the laws of action of what we call matter has become an axiom."

The common ground of those who advocate the duty of belief and those who insist on the duty of doubt is clear. Both are agreed as to the necessity of accepting whatever has sufficient evidence to support it; both agree that there is room for doubt though not necessarily for rejection in cases where the evidence is contaminated or insufficient. It is in the application that the difference lies. The scientific theologian admits the agnostic principle, however widely his results may differ from those reached by the majority of agnostics. "But, as between agnosticism and ecclesiasticism, or, as our neighbours across the Channel call it, clericalism, there can be neither peace nor truce. The cleric

asserts that it is morally wrong not to believe certain propositions, whatever the results of a strict scientific investigation of the evidence of these propositions. He tells us that 'religious error is, in itself, of an immoral nature' (Newman). It necessarily follows that, for him, the attainment of faith, not the ascertainment of truth, is the highest aim of mental life."

Huxley helped largely in the modern movement which has made it impossible to blame people for doubt, and this was what he strove for most strenuously. Freedom of thought, like freedom of the Press, by no means implies that what is free must necessarily be good. In both cases there may be a rank growth of weeds, nurtured in vicious imagination, and finding a ready market with the credulous mob. For the detection and rejection of these, the critical method of science serves as well as it does against the loftier errors supported by authority.

Huxley was a strict Puritan even as the champion of free thought, and had no sympathy with those who used the great historical weapon of ribaldry against religious dogma. He was appealed to for help in a well-known case, but replied: "I have not read the writings for which Mr. Foote has been prosecuted. But, unless their nature has been grossly misrepresented, I cannot say that I feel disposed to intervene on his behalf.

"I am ready to go to great lengths in defence of freedom of discussion, but I decline to admit that rightful freedom is attacked, when a man is prevented from coarsely and brutally insulting his neighbours' honest beliefs." But there was a sting in the tail, lest he should be too readily claimed for the side to which he was opposed. He went on:

"I would rather make an effort to get legal penalties inflicted with equal rigour on some of the anti-scientific blasphemers—who are quite as coarse and unmannerly in their attacks on opinions worthy of all respect as Mr. Foote can possibly have been."

It was on Descartes and on Hume that Huxley founded the precise form in which he urged the

duty of doubt, and his exact words are worth quoting.

"It was in 1619, while meditating in solitary winter quarters, that Descartes (being about the same age as Hume when he wrote the *Treatise on Human Nature*) made that famous resolution, to 'take nothing for truth without clear knowledge that it is such,' the great practical effect of which is the sanctification of doubt; the recognition that the profession of belief in propositions, of the truth of which there is no sufficient evidence, is immoral; the discrowning of authority as such; the repudiation of the confusion, beloved of sophists of all sorts, between free assent and merely piously gagged dissent, and the admission of the obligation to reconsider even one's own axioms on due demand."

This was the healthy and active scepticism which took no direct pleasure in doubting, but used doubt only as a means of making knowledge doubly secure, and which prevented false ideas being bolstered up by privilege or by tyranny.

"The development of exact natural knowledge in all its vast range, from physics to history and criticism, is the consequence of the working out, in this province, of the resolution to take nothing for truth without clear knowledge that it is such; to consider all beliefs open to criticism; to regard the value of authority as neither greater nor less than as much as it can prove itself to be worth. The modern spirit is not the spirit 'which always denies,' delighting only in destruction; still less is it that which builds castles in the air rather than not construct; it is the spirit which works and will work 'without haste and without rest,' gathering harvest after harvest of truth into its barns and devouring error with unquenchable fire."

It is a special weakness of the modern human race to love inventing descriptive names by which particular modes of thought may be classified and labelled. In order to meet this demand, Huxley invented the word *agnosticism*, to serve as a label for his own attitude. The word rapidly became popular, and attempts were made to read into it far more than its inventor implied. For him it was no

definite body of doctrine, no creed in any positive sense. It merely expressed the attitude he assumed towards all problems on which he regarded the evidence as insufficient. It was a habit of mind rather than a series of opinions or beliefs; an intellectual weapon and not materials on which to exercise the intellect.

Hume had written that "the justest and most plausible objection against a considerable part of metaphysics is that they are not properly a science, but arise either from the fruitless efforts of human vanity, which would penetrate into subjects utterly inaccessible to the human understanding, or from the craft of popular superstitions, which, being unable to defend themselves on fair ground, raise these entangling brambles to cover and protect them." In these considerations he found reason not for leaving superstition in possession of its ground, but for making a bold and arduous attack upon it in its haunts. The great difficulty in the way of carrying the war into the enemy's own camp was that in those days so-called science was itself cumbered with many illogical and metaphysical ideas, and for the first time in the present century the great advances of physical science, and, in particular, the renewed life poured by Darwin into the doctrine of evolution, made it possible to bring a new series of exact arguments against hazy metaphysical dogmas. The militant side of agnosticism was directed against the camp of superstition and armed with the new weapons of exact science. Its stern rejection of belief unsupported by adequate evidence was a challenge to all the adherents of the sanguine philosophy which replaces proof by assured and emphatic statement and restatement. It is possible, although rare, for those who hold a positive belief upon evidence, howsoever insufficient, to leave their doubting neighbours in peace, and these neighbours, assured in their own beliefs, equally positive and perhaps equally unfounded, may return the lazy tolerance. But the agnostic position is at once a reproof and a challenge to all who do not hold it. Perhaps no one has ever put

the agnostic attitude more clearly than Kant when he wrote that "the greatest and perhaps sole use of all philosophy of pure reason, is, after all, merely negative, since it serves, not as an organon (for the enlargement of knowledge), but as a discipline for its delimitation: and instead of discovering truth has only the modest merit of preventing error." It is precisely because it is addressed against error that agnosticism brought not peace but a sword; precisely because, instead of adding to the beliefs of the world, it sought to examine them and perhaps by the examination to diminish them, that it aroused passionate resentment. In this respect it stands separate and apart from any other attitude, as all these implied a definite acceptance or rejection of some definite propositions. Agnosticism means none of these things. Huxley said of it:

"Agnosticism, in fact, is not a creed but a method, the essence of which lies in a rigorous application of a single principle. That principle is of great antiquity; it is as old as Socrates; as old as the writer who said, 'Try all things, hold fast by that which is good'; it is the foundation of the Reformation, which simply illustrated the axiom that every man should be able to give reason for the faith that is in him; it is the great principle of Descartes; it is the fundamental axiom of modern science. Positively the principle may be expressed: In matters of the intellect, follow your reason as far as it will take you, without regard to any other consideration. And negatively: In matters of the intellect, do not pretend that conclusions are certain which are not demonstrated or demonstrable. That I take to be the agnostic faith, which, if a man keep whole and undefiled, he shall not be ashamed to look the universe in the face, whatever the future may have in store for him."

CHAPTER XV

THE BIBLE AND MIRACLES

HUXLEY was by training and habit of mind a naturalist, busy with dissections and drawing, pursuing his branch of science for itself and with no concern as to its possible relation to philosophical speculation or religious dogma. It is possible that, under different conditions, his intellectual activities might have been spent entirely on his scientific work. As it was, he became almost more widely known as a hostile critic of accepted religious doctrine than as a man of science. Many causes contributed to this effect, but the chief reason was the contemporary attitude of the churches to Darwinism. He tells us as a matter of fact that in 1850, nine years before the appearance of *The Origin of Species*, he had "long done with the Pentateuchal cosmogony which had been impressed on his childish understanding as divine truth." In a chapter he contributed to the *Life of Darwin* he wrote that in his opinion "the doctrine of evolution does not even come into contact with theism, considered as a philosophical doctrine." The reason of his general attitude to the Bible was simply that his application of the agnostic method to it led him to the view that there was not sufficient evidence for the pretensions assigned to it; the reason of his coming forward as a public and active champion of his views in this matter was partly to make a counter attack on the enemies of science, and partly his innate respect for the propagation of truth. He had the inevitable respect of an Englishman for the English Bible as one of

the greatest books in our language, and we have seen how he had advocated its adoption in schools. He had the veneration for its ethical contents common to the best thinkers of all ages since it came into existence, and few writers have ever employed loftier or more direct language to express their respect and admiration. As a venerator of freedom and of liberty he regarded the Bible as the greatest text-book of freedom.

"Throughout the history of the Western world," he wrote, "the Scriptures, Jewish and Christian, have been the great instigators of revolt against the worst forms of clerical and political despotism. The Bible has been the *Magna Charta* of the poor and of the oppressed; down to modern times no State has had a constitution in which the interests of the people are so largely taken into account, in which the duties, so much more than the privileges, of rulers are insisted upon, as that drawn up for Israel in Deuteronomy and in Leviticus; nowhere is the fundamental truth that the welfare of the State, in the long run, depends on the uprightness of the citizen so strongly laid down. Assuredly the Bible talks no trash about the rights of man; but it insists on the equality of duties, on the liberty to bring about that righteousness which is somewhat different from struggling for 'rights'; on the fraternity of taking thought for one's neighbour as for oneself."

It was not against the Bible but against the applications made of it and implications read into it that he strove.

"In this nineteenth century, as at the dawn of modern physical science, the cosmogony of the semi-barbarous Hebrew is the incubus of the philosopher and the opprobrium of the orthodox. Who shall number the patient and earnest seekers after truth, from the days of Galileo until now, whose lives have been embittered and their good name blasted by the mistaken zeal of Bibliolators? Who shall count the host of weaker men whose sense of truth has been destroyed in the effort to harmonise impossibilities—whose life has been wasted in the attempt to force the generous new wine of science into the old bottles of Judaism, compelled by the outcry of the same strong

party? It is true that if philosophers have suffered, their cause has been amply avenged. Extinguished theologians lie about the cradle of every science as the strangled snakes beside that of Hercules; and history records that whenever science and orthodoxy have been fairly opposed, the latter has been forced to retire from the lists, bleeding and crushed, if not annihilated; scotched, if not slain. But orthodoxy is the Bourbon of the world of thought. It learns not, neither can it forget; and though, at present, bewildered and afraid to move, it is as willing as ever to insist that the first chapter of Genesis contains the beginning and the end of sound science; and to visit, with such petty thunderbolts as its half-paralysed hands can hurl, those who refuse to degrade Nature to the level of primitive Judaism."

These words were written in 1860 and events have moved rapidly since Huxley wrote them. There is now practically no religious body containing a proportion of educated persons which does not allow within it a very wide range of opinion as to the inspiration of the Scriptures, the Biblical account of the Creation, the miraculous events of the Old Testament and the recorded miracles of the New. In 1900 Dr. St. George Mivart, a distinguished Catholic zoologist and long an opponent of Huxley, declared that within the Catholic Church itself a number of educated persons were prepared to accept most of Huxley's positions, as well as views more extremely iconoclastic than any advanced by Huxley. Although Dr. Mivart's outspoken words called down on him the official thunders of Rome, many good Catholics thought the exclusion of modern knowledge to be fraught with grave danger to the Church. In these matters the Protestant churches have advanced a little farther.

It was different when Huxley wrote. The first and gravest difficulty placed in the way of science was the asserted infallibility of the Scriptures. In Catholic theology, at least until late in this century, the general tendency has been to regard the Bible rather as a quarry for doctrine than as a direct means of grace. The theory of religion rested on two pillars: the inspired Scriptures containing the

necessary information and the inspired Church to interpret the Scriptures. Protestant theology had rejected the infallible inspiration of the Church, and, in consequence, had thrown a greater burden on the Scriptures. The Scriptures became the Word of God, verbally and literally true; in its extreme form this doctrine reverted almost to the ancient Rabbinical maxim that even the vowel points and accents were of divine origin. In practice, if not in theory, the halo was also extended to cover the marginal chronology, then a familiar feature in the editions of the English Bible. The present writer, even in 1888, was reproved with violence by a clergyman of considerable education and position for expressing a doubt as to the accuracy of these dates. Obviously there was no common measure between a church holding such views and advancing science. War was inevitable, until one side or the other should give way.

Huxley conducted the attack in a series of controversies extending over many years, and in which his opponents were well-known laymen such as Gladstone, St. George Mivart, the late Duke of Argyll, and many clerical dignitaries of different denominations. The most important of his contributions to these debates, as well as several isolated essays and addresses, have been collected in two volumes, *Science and the Hebrew Tradition*, and *Science and the Christian Tradition*.

The first stage in the controversy, and the stage most immediately pressing, was to shew that the Bible was misleading and inaccurate as a record of scientific fact, and that therefore it could not be brought forward as evidence against scientific doctrines supported by scientific evidence. The vital matter in this was the account given in Genesis of the origin of the world. If that disappeared then the whole ground was gained; science would be left free in its own sphere.

In a lecture on Evolution, delivered in 1876, Huxley began by discussing the possibilities as to the past history of nature. He believed that there were only three hypotheses which had been enter-

tained or which could be entertained respecting this history. The first was to assume that phenomena of nature similar to those exhibited by the world at present had always existed; in fact that the universe had existed from all eternity in what might be termed, broadly, its present condition. The second hypothesis was that the present condition of things had been of a limited duration, and that, at some period of the past, what we now know came into existence without any relation of natural causation to an antecedent state. The third hypothesis also assigned to the present condition of things a limited duration, but it supposed the existing condition to have been derived by natural processes from an antecedent condition, the hypothesis attempting to set no limits to the series of changes.

In a certain sense, the first hypothesis recalls the doctrine of uniformitarianism of Hutton and Lyell. But, although it is no longer necessary to imagine the past history of the earth as a series of gigantic catastrophes, yet the whole record of science is against the supposition that anything like the existing state of nature has had an eternal duration. The record of fossils shews that the living population of the earth has been entirely different at different epochs. Geological history shews that, whether these changes have come about by swift catastrophes, or by slow, enduring movements, the surface of the globe, its distribution into land and water, the character of these areas and the conditions of climate to which they have been subjected have passed through changes on a colossal scale. Moreover, if we look from this earth to the universe of stars and suns and planets, we see everywhere evidence of unceasing change. If we use scientific observation and reason, if we employ on the problem the only means we possess for attempting its solution, we cannot accept the hypothesis that the present condition of nature has been eternal.

"So far as that limited revelation of the nature of things, which we call scientific knowledge, has yet

gone, it tends, with constantly increasing emphasis, to the belief that, not merely the world of plants, but that of animals; not merely living things but the whole fabric of the earth; not merely our planet but the whole solar system, not merely our star and its satellites, but the millions of similar bodies which bear witness to the order which pervades boundless space and has endured through boundless time, are all working out their predestined courses of evolution."

The second hypothesis is familiar to us in the sacred records of many religions and in the Hebrew Scriptures. Most of these have a fundamental similarity, inasmuch as they offer pictures in which the mode and order of creation are given in the minutest detail and with the simplest kind of anthropomorphism; in which the Creator is represented with familiar human characteristics. But these general considerations, so obvious now that we have learned to read the Bible narrative without passion or prejudice, were not plain to the early opponents of evolution, and it was necessary, step by step, to shew not only that the narrative in Genesis could not be reconciled with known facts if it were accepted in its literal meaning, but that the most strained interpretation of the language failed to bring it into accordance with scientific truth. Gladstone was the latest and most vigorous of those who attempted to reconcile Genesis with modern knowledge, and in his controversy with Huxley he brought to bear all the resources of an acute intellect trained by long practice in the devices of argument and inspired by a lofty if mistaken enthusiasm. In the course of his argument he wrote:

"But the question is not here of a lofty poem, or a skilfully constructed narrative; it is whether natural science, in the patient exercise of its high calling to examine facts, finds that the works of God cry out against what we have fondly believed to be His word and tell another tale; or whether, in this nineteenth century of Christian progress, it substantially echoes back the majestic sound, which, before it existed as a pursuit, went forth into all lands.

"First, looking largely at the latter portion of the narrative, which describes the creation of living organisms, and waiving details, on some of which (as in v. 24) the Septuagint seems to vary from the Hebrew, there is a grand fourfold division, set forth in an orderly succession of times as follows: on the fifth day

1. The water-population.
2. The air-population.

and, on the sixth day,

3. The land-population of animals.
4. The land-population consummated in man.

"Now this same fourfold order is understood to have been so affirmed in our time by natural science, that it may be taken as a demonstrated conclusion and established fact."

The defence itself shewed that already a large part of the original position had been abandoned. The literal meaning and belief in detailed accuracy were given up and Gladstone sought to establish only a general correspondence between the Biblical narrative and the results of science. But even in that form Huxley shewed the defence to be untenable.

"I can meet the statement in the last paragraph of the above citation," he replied, "with nothing but a direct negative. If I know anything at all about the results attained by the natural science of our time, it is a 'demonstrated conclusion and established fact' that the fourfold order given by Mr. Gladstone is not that in which the evidence at our disposal tends to shew that the water, air, and land populations of our globe made their appearance."

With the most voluminous detail, he proceeds to shew that there is no possible relation between the order implied by the narrative and the order as revealed by science. Let us sum up, by two quotations, the result of the whole controversy. First, the literal meaning in untenable.

"The question whether the earth and the immediate progenitors of its present living population were made in six natural days or not is no longer one on which two opinions can be held. The fact that it did not come so into being stands upon as sound a basis

as any fact of history whatever. It is not true that existing plants and animals came into being within three days of the creation of the earth out of nothing, for it is certain that innumerable generations of other plants and animals lived upon the earth before its present population. And when, Sunday after Sunday, men who profess to be our instructors in righteousness read out the statement, 'In six days the Lord made heaven and earth, the sea, and all that in them is,' in innumerable churches, they are either propagating what they may easily know, and, therefore, are bound to know, to be falsities; or, if they use the words in some non-natural sense, they fall below the moral standard of the much-abused Jesuit."

The attenuated meaning equally must be given up.

"Even if they (the reconcilers) now allow that the words 'the evening and the morning' have not the least reference to a natural day, but mean a period of any number of millions of years that may be necessary; even if they are driven to admit that the word 'creation,' which so many millions of pious Jews and Christians have held, and still hold, to mean a sudden act of the Deity, signifies a process of gradual evolution of one species from another, extending through immeasurable time; even if they are willing to grant that the asserted coincidence of the order of nature with the 'fourfold order' ascribed to Genesis is an obvious error instead of an established truth, they are surely prepared to make a last stand upon the conception which underlies the whole, and which constitutes the essence of Mr. Gladstone's 'fourfold division, set forth in an orderly succession of times.' It is that the animal species which compose the water-population, the air-population, and the land-population, respectively, originated during three distinct and successive periods of time, and only during these periods of time. . . . But even this sublimated essence of the Pentateuchal doctrine remains as discordant with natural science as ever."

There remains the third, or evolutionary hypothesis regarding the origin of the existing order of nature. As Huxley held it, it was rigidly limited within the possibilities afforded by the agnostic attitude. With regard to the real nature, the origin and destiny of the whole universe, there was not

sufficient evidence before the human mind, if indeed the human mind were capable of receiving such evidence, to come to any conclusion. For the rest, for the actual condition of the earth itself, science was gradually accumulating overwhelming evidence in favour of a continuous evolution, under natural agencies, from the beginning of life to the existing forms of animals and plants, and the actual origin of life from inorganic matter under similarly natural agencies was becoming more and more a legitimate inference.

Huxley's relation to the New Testament may be summed up in few words. It was simply that there was not sufficient evidence for ascribing to it the supernatural sanction demanded for it by dogmatic theology.

"From the dawn of scientific Biblical criticism until the present day, the evidence against the long-cherished notion that the three synoptic gospels are the work of three independent authors, each prompted by Divine inspiration, has steadily accumulated, until, at the present time, there is no visible escape from the conclusion that each of the three is a compilation consisting of a groundwork common to all three—the threefold tradition; and of a superstructure consisting, firstly, of matter common to it with one of the others, and, secondly, of matter common to each."

Again :—"There is no proof, nothing more than a fair presumption, that any one of the gospels existed, in the state in which we find it in the authorised version of the Bible, before the second century, or, in other words, sixty or seventy years after the events recorded." These considerations with slight differences in details are now practically admitted among the abler apologists, with the result that, as Huxley claimed, the New Testament, like the Old, must be treated as literature rather than as dogma. As literature everyone has the right to examine the contents critically, and, considering the importance attributed to the contents, the right becomes a duty. No doubt, had Huxley not lived there would have been others equally ready and equally able to gain the battle for freedom of

thought in its special application to the claim of the Bible to stand in the way of the advance of scientific knowledge; but as it is, it cannot be denied that the existing prevalence of liberal views, inside and outside the churches, on the nature and interpretation of the Scriptures is largely due to him.

After the question of inspiration, the most striking feature of the Bible is its appeal to miracles and the miraculous element. Two great *a priori* difficulties have been brought against accepting any record of miracles as true. The first of these is very simple, depending on the history of all times and peoples. It is that the human race has shewn itself universally credulous in this matter. It has cried "Wolf!" so readily, so honestly, and on so many occasions that the cry has ceased to carry conviction with it. Every religion has its series of miraculous events; every savage tribe and every uneducated race has its miracle-workers implicitly accepted. In mediæval and modern Europe up to our own times, miracles have been so constantly recorded on testimony of such undoubted integrity that we must believe either that miracles can be performed by numberless persons with no other claim to special regard, or that it is singularly easy to get false but honest evidence regarding them. Huxley supported the latter alternative strongly, and held the view that to believe in any particular miracles would require evidence very much more direct and very much stronger than would be necessary in the case of inherently probable events.

The second *a priori* objection to the credibility of miracles has been urged more strongly, but was not accepted by Huxley. It is that miracles are obviously incredible inasmuch as they are "violations of the order of nature." Hume, attacking miracles, had made this objection the chief ground of his argument. Huxley paid a logical respect, at least as great, to the continuity of nature.

"When the experience of generation after generation is recorded, and a single book tells us more than Methuselah could have learned, had he spent every waking hour of his thousand years in learning; when

apparent disorders are found to be only the recurrent pulses of a slow-working order, and the wonder of a year becomes the commonplace of a century; when repeated and minute examination never reveals a break in the chain of causes and effects; and the whole edifice of practical life is built upon our faith in its continuity; the belief that that chain has never been broken and will never be broken, becomes one of the strongest and most justifiable of human convictions. And it must be admitted to be a reasonable request, if we ask those who would have us put faith in the actual occurrence of interruptions of that order, to produce evidence in favour of their view, not only equal, but superior, in weight, to that which leads us to adopt ours."

But out of the mouth of Hume himself he declared against making the recorded experience of man, however lengthy and impressive, a necessary ground for rejecting the possibility of the miraculous. Hume had said, " Whatever is intelligible and can be distinctly conceived implies no contradiction, and can never be proved false by any demonstration, argument, or reasoning, *a priori*." This or the like applies to most of the recorded miracles. Huxley was extremely careful not to assert that they were incredible merely because they might involve conditions outside our existing experience. It is a vulgar mistake, for which science certainly gives no warrant, to assert that things are impossible because they contradict our experience. In such a sense many of the most common modern conveniences of life would have seemed impossible a century ago. To travel with safety sixty miles an hour, to talk through the telephone with a friend a hundred miles away, to receive intelligible messages across the Atlantic by a cable, and, still more, to communicate by wireless telegraphy would have seemed impossible until recently. At the present time, the conversion of a baser metal into gold would be called impossible by everyone with a little knowledge of elementary chemistry. This last example leads admirably to a right understanding of the scientific view of impossibility. The older alchemists, partly from ignorance and

partly from credulity, believed absolutely in the possibility of transmuting the metals. The advance of chemical science led to definite conceptions of the differences between compounds and elementary bodies, and of the independence of these elements. The methods and reasoning of the alchemists became absurd, and no one would attempt seriously to transmute the metals on their lines. These advances, however, do not give us the right to assume that the elements are absolutely independent, and that transmutation is therefore impossible. Some of the most recent progress in chemistry has opened up the suggestion that the elements themselves are different combinations of a common substance. Huxley applied this particular argument to the miracle at the marriage of Cana.

"You are quite mistaken in supposing that anybody who is acquainted with the possibilities of physical science will undertake categorically to deny that water may be turned into wine. Many very competent judges are inclined to think that the bodies which we have hitherto regarded as elementary are really composite arrangements of the particles of a uniform primitive matter. Supposing that view to be correct, there would be no more theoretical difficulty about turning water into alcohol, ethereal and colouring matters, than there is, at this present moment, any practical difficulty in working other such miracles; as when we turn sugar into alcohol, carbonic acid, glycerine, and succinic acid; or transmute gas-refuse into perfumes rarer than musk and dyes richer than Tyrian purple."

Unless we make the unscientific and preposterous assumption that our present knowledge of nature and of natural forces is absolute and complete, it is unscientific and illogical to declare at once that any supposed events could not have happened merely because they seem to have contradicted so-called natural laws.

"Strictly speaking," Huxley wrote, "I am unaware of anything that has a right to the title of an 'impossibility' except a contradiction in terms. There are impossibilities logical, but none natural. A 'round

square,' a 'present past,' 'two parallel lines that intersect,' are impossibilities, because the ideas denoted by the predicates, round, present, intersect, are contradictory of the ideas denoted by the subjects, square, past, parallel. But walking on water, or turning water into wine, or procreation without male intervention, or raising the dead, are plainly not impossibilities in this sense."

The whole matter turns on the question of sufficient evidence.

"Hume's arguments resolve themselves into a simple statement of the dictates of common sense which may be expressed in this canon: the more a statement of fact conflicts with previous experience, the more complete must be the evidence which is to justify us in believing it."

Again, expressing the same idea in different words, he wrote:

"Nobody can presume to say what the order of nature must be; all that the widest experience (even if it extended over all past time and through all space) that events had happened in a certain way could justify, would be a proportionately strong expectation that events will go on so happening, and the demand for a proportional strength of evidence in favour of any assertion that they had happened otherwise. It is this weighty consideration, the truth of which everyone who is capable of logical thought must surely admit, which knocks the bottom out of all *a priori* objections either to ordinary 'miracles' or to the efficacy of prayer, in so far as the latter implies the miraculous intervention of a higher power. No one is entitled to say, *a priori*, that prayer for some change in the ordinary course of nature cannot possibly avail."

It was a question of evidence, and not only did the evidence not convince Huxley, but the thaumaturgic nature of the Biblical miracles provided him with additional reason for refusing to attach any extrinsic value to the contents of the book.

On the other hand, although he declined to accept the Bible as a miraculous and authentic revelation, again and again he expressed himself in the strongest terms as to its value to mankind,

and as to the impossibility of any scientific advance diminishing in any way whatsoever that value.

"The antagonism between religion and science, about which we hear so much, appears to me to be purely factitious—fabricated, on the one hand, by shortsighted religious people who confound a certain branch of science, theology, with religion; and, on the other, by equally shortsighted scientific people who forget that science takes for its province only that which is susceptible of clear intellectual comprehension; and that outside the boundaries of that province, they must be content with imagination, with hope, and with ignorance."

And again;

"In the eighth century B.C., in the heart of a world of idolatrous polytheists, the Hebrew prophets put forth a conception of religion which appears to me to be as wonderful an inspiration of genius as the art of Pheidias or the science of Aristotle. 'And what doth the Lord require of thee, but to do justly, and to love mercy, and to walk humbly with thy God?' If any so-called religion takes away from this great saying of Micah, I think it wantonly mutilates, while if it adds thereto, I think it obscures, the perfect ideal of religion."

CHAPTER XVI

ETHICS OF THE COSMOS

WE have seen that Huxley refused to acquiesce in the current orthodox doctrine that our systems of morality rested on a special revelation, miraculous in its origin, and vouched for by the recorded miracles of its Founder, or by those entrusted by the Founder with miraculous power. He supported the view that, historically and actually, there is no necessary connection between religion and morality. The one is an attempt, in his opinion always unsuccessful, to lift the veil from the unseen, to know the unknowable; the other is simply the code that social man, through the ages, has elaborated for his own guidance, and proved by his own experience. So far as the conduct of life goes, the morality of one who accepts the agnostic position with regard to revelation and the unseen universe differs in no respect from the code taken under the protection of the modern forms of religion. As Lord Morley, in his *Essay on Voltaire* wrote of such a person :

"There are new solutions for him, if the old have fallen dumb. If he no longer believe death to be a stroke from the sword of God's justice, but the leaden footfall of an inflexible law of matter, the humility of his awe is deepened, and the tenderness of his pity made holier, that creatures who can love so much should have their days so shut round with a wall of darkness. The purifying anguish of remorse will be stronger, not weaker, when he has trained himself to look upon every wrong in thought, every duty omitted from act, each infringement of the inner spiritual law which humanity is constantly perfecting

for its own guidance and advantage, less as a breach of the decrees of an unseen tribunal than as an ungrateful infection weakening and corrupting the future of his brothers."

But there are wider questions than the immediate problems of conduct. A certain type of mind finds it almost impossible not to attempt ethical judgments on the whole universe, not to speculate whether the Cosmos, as we can imagine it from the part of it within the cognisance of man, offers a spectacle of moral or immoral or of non-moral significance. In the old times of Greece and in the modern world many have been devoid of the taste for argument on such subjects. Those who are uninterested in these abstract discussions are rarely in opposition to the mode of faith surrounding them, for to reject the doctrines held by the majority of one's friends and associates implies either a disagreeable disposition or an unusual interest in ultimate problems; they are usually orthodox according to their environment—Stoics, Epicureans, Jews, Episcopalians, Catholics, Quakers, Methodists, Mormons, Mohammedans, Buddhists, or whatever may be the prevailing dogma around them. The attitude of indifference to moral philosophy has practically no relation to what may be considered good or bad moral conduct; those characterised by it live above or below or round about their own moral standards in a fashion as variable as that of moral philosophers. Many of the saints, ancient and modern, have been notorious instances; question them as to their faith or as to the logical foundation of their renunciations and they will tell you in simple honesty or make it plain by their answers that they have no head for logic, that they cannot argue, but only know and feel their position to be true. In addition to the saints, many of the best and most of the pleasant people in the world are of this type.

The type strongly in contrast with the foregoing is found in persons of a more strenuous, perhaps more admirable but less agreeable character. The savour of acerbity may be a natural attribute of the

critical character, and it is certainly not lessened where moral philosophy is the subject-matter of the criticism. The continual search after solutions of problems that may be insoluble at least makes the seekers acute judges of wrong solutions. Like Luther and Loyola and Kant, they may be able to satisfy themselves, or, like Huxley, they may remain in doubt, but in either case they are excellent critics of the solutions of others. They are the firebrands of faith or of negation; they are possessed by an intellectual fury that will not let them cease from propagandising. They must go through the world as missionaries; and the missionary spirit is dual, one side zealous to proclaim the new, the other equally zealous to denounce the old. But theirs is the great work, "to burn old falsehood bare," to tear away the incrustations of time which people have come to accept as the thing itself, and in their track new and lively truth springs up, as fresh green follows the devastations of fire.

To most of us it seems of sufficient importance and of sufficient difficulty to make our decisions in the little eddies of good and evil that form as the world-stream breaks round our individual lives. Huxley strove to interpret the world-stream itself, to translate its movements into the ethical language of man. As knowledge of the forces and movements of the Cosmos has increased so has our general conception been intensified, our conception of it as a wondrous display of power and grandeur and superhuman fixity of order. But are the forces of the Cosmos good or evil? Are we, and the Cosmos of which we are a part, the sport of changeable and capricious deities, the pawns in a game of the gods, as some of the Greeks held; or of a power drunkenly malicious, as Heine once cynically suggested; or a battle-ground for a force of good and a force of evil as in so many Eastern religions? Are we dominated by pure evil, as some dark creeds have held, or by pure good, as the religion of the Western world teaches? And if we are dominated by pure evil, whence come good and the idea of

good, or, if by pure good, whence evil and the idea of evil?

Huxley's interest in these great problems appears and reappears throughout his published writings, but his views are most clearly and systematically exposed in his "Romanes" lecture on "Evolution and Ethics" delivered and published at Oxford in 1894, and afterwards republished with a prefatory essay in the last volume of his *Collected Essays*. Not long before his death, Professor Romanes, who had come to live in Oxford, founded a University lectureship, the purpose of which was that once a year a distinguished man should address the University on a subject neither religious nor political. Gladstone was the first lecturer, and, at the suggestion of the founder, Huxley was chosen as the second. For years he had been taking a special interest in both religion and politics, and he was not a little embarrassed by the restrictions imposed by the terms of the foundation, for he determined to make ethical science the subject of his address, and

> "ethical science is, on all sides, so entangled with religion and politics, that the lecturer who essays to touch the former without coming in contact with either of the latter, needs all the dexterity of an egg-dancer, and may even discover that his sense of clearness and his sense of propriety come into conflict, by no means to the advantage of the former."

As Huxley, on that great occasion, ascended the rostrum in the Sheldonian theatre, very white and frail in his doctor's scarlet robes, there must have been present in his mind memories of the occasion, four-and-thirty years before, when he first addressed an audience in the University of Oxford. Then he was a young man, almost unknown, rising to lead what seemed a forlorn hope for an idea utterly repugnant to most of his hearers. Now, and largely by his own efforts, the idea had become an inseparable part of human thought, and Huxley himself was the guest to whom the whole University was doing honour. Graduates from all parts of England

had come to hear what, it was feared, might be his last public speech, and practically every member of the University who could gain admission was present. The Press of the world attended to report his words as if they were those of a great political leader, about to decide the fate of nations. Although his voice had lost much of its old sonorous reach, and although the old clear rhythms were occasionally broken by hesitancies, the magic of his personality oriented to him every face.

It is a curious and striking circumstance, a circumstance fully recognised by Huxley himself, that in this exposition of his ethical conception of the Cosmos he reconstructed, on the lines of his evolutionary philosophy, one of the oldest and most widespread theories, a theory again and again reached by men of different civilisations and epochs. Manes, the Persian, from whose name the word "Manicheism" has been coined to denote his doctrine, taught in perhaps the most explicit fashion that the Cosmos was the battle-ground of two contending powers—Ahriman, the principle of evil, and Ormuzd, the principle of good. This doctrine in some form or other is implicit in most of the greater religions, some of which have assumed an ultimate triumph for the principle of good, while others have left the issue doubtful. The Ahriman of Huxley, the principle of evil, is what he termed the cosmic process, that great play of forces, by which, in a ruthless struggle for existence, the fittest (that is to say the most suited to the surrounding conditions and not necessarily the ethically best) have survived at the expense of the less fit. The Ormuzd, the principle of good, is what Huxley called the Ethical process, the process by which sentient, intelligent, and moral man has striven to replace the "old ape and tiger methods" of the cosmic process, by methods in which justice and mercy, sacrifice and consideration for others have a part.

To explain clearly the distinction he made between the ethical and cosmic processes, Huxley, in the prefatory essay ("Prolegomena") published

in the volume with his Romanes lecture, developed the analogy of a cultivated garden reclaimed from surrounding wild nature. He described how the countryside, visible from his windows at Eastbourne, had certainly been in a "state of nature" about two thousand years ago when Cæsar had set foot in Britain and had made the Roman camps, the remains of which still mark the chalk downs of England.

"Except, it may be, by raising a few sepulchral mounds, such as those which still, here and there, break the flowing contours of the Downs, man's hands had made no mark upon it; and the thin veil of vegetation which overspread the broad-backed heights and the shelving sides of the coombs was unaffected by his industry. The native grasses and weeds, the scattered patches of gorse, contended with one another for possession of the scanty surface soil; they fought against the droughts of summer, the frosts of winter, and the furious gales, which swept with unbroken force, now from the Atlantic, and now from the North Sea, at all times of the year; they filled up, as they best might, the gaps made in their ranks by all sorts of overground and underground ravagers. One year with another, an average population, the floating balance of the unceasing struggle for existence among the indigenous plants, maintained itself. It is as little to be doubted that an essentially similar state of nature prevailed in this region for many thousand years before the coming of Cæsar; and there is no assignable reason for denying that it might continue to exist through an equally prolonged futurity except for the intervention of man."

This present state of nature, he explained, is only a fleeting phase of a process that has gone on for millions of years. Under the thin layer of soil are the chalk cliffs, hundreds of feet thick and witnesses of the entirely different phases of the struggle that went on while the cliffs were being formed at the bottom of the chalk sea, when the vegetation of the nearest land was as different from the existing vegetation as that is different from the trees and flowers of an African forest.

"Before the deposition of the chalk, a vastly longer period elapsed, throughout which it is easy to follow the traces of the same process of ceaseless, modification and of the same internecine struggle for existence of living things; and when we can go no further back, it is not because there is any reason to think we have reached the beginning, but because the trail of the most ancient life remains hidden or has become obliterated."

The state of nature, then, is a fleeting and impermanent process.

"That which endures is not one or other association of living forms, but the process of which the Cosmos is the product and of which these are among the transitory expressions. And in the living world, one of the most characteristic features of this cosmic process is the struggle for existence, the competition of each with all, the result of which is the selection, that is to say, the survival of those forms which, on the whole, are best adapted to the conditions which at any period obtain; and which are, therefore, in that respect, and only in that respect, the fittest. The acme reached by the cosmic process in the vegetation of the Downs is seen in the turf with its weeds and gorse. Under the conditions they have come out of the struggle victorious; and, by surviving, have proved that they are the fittest to survive."

For three or four years, the state of nature in a small portion of the Downs surrounding Huxley's house had been put an end to by the intervention of man.

"The patch was cut off from the rest by a wall; within the area thus protected the native vegetation was, as far as possible, extirpated, while a colony of strange plants was imported and set down in its place. In short, it was made into a garden. This artificially treated area presents an aspect extraordinarily different from that of so much of the land as still remains in the state of nature outside the wall. Trees, shrubs and herbs, many of them appertaining to the state of nature in remote parts of the globe, abound and flourish. Moreover, considerable quantities of vegetables, fruit, and flowers are produced, of kinds which neither now exist nor have ever existed except under conditions such as obtain in the

garden and which therefore are as much works of the art of man as the frames and glass-houses in which some of them are raised. That the 'state of art' thus created in the state of nature by man, is sustained by and dependent on him, would at once become apparent if the watchful supervision of the gardener were withdrawn, and the antagonistic influences of the general cosmic process were no longer sedulously warded off, or counteracted."

He proceeds to describe how, under such circumstances, the artificial barriers would decay, and the delicate inhabitants of the garden would perish under the assaults of animal and vegetable foes. External forces would reassert themselves and wild nature would resume its sway. While, in a sense, he had strenuously advocated the unity of all nature, he found in it two rivals: the artificial products of sentient man and the forces and products of wild nature. These two he believed to be in inevitable opposition and to represent the good and the evil forces of the world.

In the dim ages of the past, the forces that have gone to the making of man have been part of the cosmic process. In the endless and wonderful series of kaleidoscopic changes by which, under the operation of natural laws, the body, habits, and the character of man have been elaborated slowly from the natal dust, there is the widest field for the operation of the most acute intelligence to study and trace the stages in the process. But if intellectual delight in studying the process be left out of account, a serious question at once appears. In the higher stages of evolution the cosmic forces, ceasing to act merely on insentient matter, have operated on sentient beings, and in so doing have given rise to the mystery of pain and suffering. When the less fit of chemical combinations or even of the lower forms of life perished in the struggle, we may regard the process with the unemotional eye of pure intelligence. But "pain, the baleful product of evolution, increases in quantity and in intensity with advancing stages of animal organisation, until it attains its highest level in man." And so it

comes about that the cosmic process produces evil, sorrow, and suffering. Consideration of the cosmic process leads us against the mystery of evil.

Huxley argued that the various philosophies and civilisations of the past had led by different paths to a similar conclusion. The primitive ethical codes of man were not unlike the compacts of a wolf-pack, the understanding to refrain from mutual attack during the chase of a common prey. Conceptions of this kind became arranged in codes and invested with supernatural sanction. But in Hindustan and Ionia alike, material prosperity, no doubt partly the result of the accepted codes, produced culture of the intellect and culture of the pleasures. With these came the " beneficent demon, doubt, whose name is legion and who dwells amongst the tombs of old faiths." The doubting intellect, acting on the codes, produced the conception of justice-in-itself, of merit as divorced from the effect of action on others, the abstract idea of goodness.

The old philosopher, inspired by this new conception, found the Cosmos incompatible with goodness. Suffering and sorrow, sunshine and rain, were distributed independently of merit. With Greek and Semite and Indian the conscience of man revolted against the moral indifference of nature. Instead of bringing in a verdict of guilty, they attempted reconciliation in various ways. Indian speculation invented or elaborated the theory of transmigration, in which the Karma or soul-character passed from individual to individual, the sums of happiness in the whole chain being proportional to merit. The Stoics were metaphysicians and imagined an immanent, omnipotent, and infinitely beneficent First Cause. Evil was incompatible with this, and so they held, against experience, that either it did not exist, or that it was inflicted for our benefit or due to our fault. In one fashion or another, all the great systems of thought had recognised the antagonism and had attempted some explanation of it. Huxley's view was that the modern world with its new philosophy was only

retreading the toil-worn paths of the old. Scientific optimism was being replaced by a frank pessimism. Cosmic evolution might be accountable for both good and evil, but knowledge of it provided no better reason for choice of the good than did earlier speculation. The cosmic process was not only non-moral but immoral; goodness did not lead to success in it, and laws and moral precepts could only be addressed to the curbing of it.

In a sense these conclusions of Huxley seemed to lead to absolute pessimism, but he offered some mitigating considerations. Society remains subject to the cosmic process, but the less as civilisation advances and ethical man is the more ready to combat it. The history of civilisation shews that we have some hope of this, for "when physiology, psychology, ethics, and political science, now befogged by crude anticipations and futile analogies, have emerged from their childhood, they may work as much change on human affairs as the earlier-ripened physical sciences wrought on material progress." And so, remembering that the evil cosmic nature in us has the foothold of millions of years, and never hoping to abandon sorrow and pain, we may yet, in the manhood of our race, accept our destiny, and, with clear and steady eyes, address ourselves to the task of living, that we and others may live better.

These gloomy views come from Huxley with such weight and authority that even in a sketch of his life and opinions it may be noticed that they do not seem necessary deductions from the evolutionary conception of the world. The first count adduced against the cosmic process is its connection with suffering. It may be doubted, so far as the animal world is concerned, if Huxley has not exaggerated the gravity of this. The two greatest contributors to the modern conception of evolution are not in agreement with him. Alfred Russel Wallace wrote:

"On the whole, then, we conclude that the popular idea of the struggle for existence entailing misery and pain on the animal world is the very reverse of

the truth. What it really brings about is the maximum of life and of the enjoyment of life with the minimum of suffering and pain. Given the necessity of death and reproduction—and without those there could have been no progressive development of the animal world—and it is difficult even to imagine a system by which a greater balance of happiness could have been secured."

This view was evidently that also of Darwin himself, who thus concluded his chapter on the struggle for existence: "When we reflect on this struggle, we may console ourselves with the full belief that the war of nature is not incessant, that no fear is felt, that death is generally prompt, and that the vigorous, the healthy, and the happy survive and multiply." As for man himself, though it be true that in him the consummation of pain is reached, still this is no isolated fact of far-reaching ethical importance. It is in direct dependence on the increased physical and mental development of man, and these are equally necessary for and equally susceptible to increased pleasure and increased happiness. It is not necessary to regard the cosmic process as evil. Even when man, in various ages, had elaborated the conception of abstract goodness, and had endeavoured to make his justice a doling out of reward and punishment according to merit, it was not inevitable to bring in a verdict of guilty against the Cosmos. It is quite true that, in all the ages, man has seen the sun shine on the unjust as on the just. But it is an easy reflection that the world could not turn round on individual merit, and if few are so guilty as to deserve the agonies of grief that may come to any, still fewer deserve some of the simpler and more common joys of life. The conception that was implicit in the disciplines of the older philosophies is still open to the philosophy of evolution. Behind it, as behind the "self-hypnotised catalepsy of the devotee of Brahma," the Buddhist aspirations to Nirvana, the *apatheia* of the Stoics, there may lie a recognition of the worthlessness of the individual: an equable acceptation of one's self as part of a process: a triumph

of intelligence over selfishness. Finally, behind the sharp division made between man and the Cosmos, there still lurks one of the oldest and most enduring fallacies of the world, a fallacy that Huxley himself spent a great part of his intellectual life in discovering and routing. The fallacy is the conception of the Cosmos as something separate and apart from man, as something through which he, however briefly, passes. Thus Omar sang:

"Myself, when young, did eagerly frequent
Doctor and saint, and heard great argument
About it and about: but evermore
Came out by the same door where in I went.

"With them the seed of wisdom did I sow,
And with mine own hand wrought to make it grow;
And this was all the Harvest that I reaped—
'I came like Water, and like Wind I go.'

"Into this Universe, and *Why* not knowing
Nor *Whence*, like water willy-nilly flowing;
And out of it, like Wind along the Waste
I know not *Whither*, willy-nilly blowing."

But, the more profoundly does the conception of evolution lay hold of human thought, the more inevitable it becomes to recognise that man and all that is best in man—his aspirations, ideas, virtues, and practical and abstract justice and goodness—are just as much the product of the cosmic process and part of the Cosmos as the most sinister episodes in the struggle for existence.

CHAPTER XVII

CLOSING DAYS AND SUMMARY

HUXLEY'S life followed the quiet and even tenor of that of a professional man of science and letters. The great adventure in it was his youthful voyage on the *Rattlesnake*. That over, and his choice made in favour of science as against medicine, he settled down in London. He married happily and shared in the common joys and sorrows of domestic life. Advancement came to him steadily, and, although he was never rich, after the first few years of life in London, his income was always adequate to his moderate needs. For the greater part of his working life, he lived actually in London, in the ordinary style and with the ordinary social enjoyments of a professional man. His duties in connection with the Royal College of Science and with the Geological Survey were not arduous but constant; his time was fully occupied with these, with his scientific and literary work, with the business of scientific societies, with the occasional obligations of royal commissions, public boards, and lecturing engagements. The quiet routine of his life was diversified by his work as a Fisheries Inspector, by many visits to provincial towns to deliver lectures or addresses, by meetings of the British Association, by holidays in Switzerland, during which, with Tyndall, he made special studies of the phenomena of glaciation, and in the usual Continental resorts, and by several trips to America.

In a rough-and-ready fashion, Huxley's active life may be broken into a set of decennial periods, each

with tolerably distinctive characters. The first period, roughly from 1850 to 1860, was almost purely scientific. It was occupied by his voyage, by his transition to science as a career, his researches into the invertebrate forms of life, the beginning of his palæontological investigations, and a comparatively small amount of lecturing and literary work. The second decennium still found him employed chiefly in research, vertebrate and extinct forms absorbing most of his attention. He was occupied actively with teaching, but the dominant feature of the decennium was his assumption of the Darwinian doctrines. In connection with these latter, his literary and lecturing work increased greatly, and the side issues of what was, in itself, purely a scientific controversy, began to lead him into metaphysical and religious studies. The third period, from 1870 to 1880, was considerably different in character. He had become the most prominent man in biological science in England, at a time when biological science was attracting a quite unusual amount of scientific and public attention. Public honours and public duties, some of them scientific, others general, began to crowd upon him, and the time at his disposal for the quiet labours of investigation became rapidly more limited within this period. He was secretary of the Royal society, a member of the London School Board, president of the British Association, Lord Rector at several universities, member of many royal commissions, government inspector of fisheries, president of the Geological Society. In this multitude of duties it was natural that the bulk of strictly scientific output was limited, but, on the other hand, his literary output was much larger. Between 1880 and 1890 he had reached the full maturity of a splendid reputation, and honours and duties pressed thick upon him. For part of the time he was president of the Royal Society, the most distinguished position to which a scientific man in England can attain, and he was held by the general public at least in as high esteem as by his scientific contemporaries. A small amount of original scientific

work still appeared from his pen, but he was occupied chiefly with more general contributions to thought.

Throughout his life, Huxley had never been robust. From his youth upwards he had been troubled by dyspepsia with its usual accompaniment of occasional fits of severe mental and physical depression. In 1872 he was compelled to take a long holiday in Egypt, and although he returned to resume full labour, it is doubtful if from that time onwards he recovered even the strength normal to him. In 1885, his ill-health became grave; in the following years he had two attacks of pleurisy, and symptoms of cardiac mischief became pressing. He gradually withdrew from his official posts, and, in 1890, retired to Eastbourne, where he had built a house high up on the Downs. The more healthy conditions and the comparative leisure he permitted himself had a good effect, and he was able to write some of his most brilliant essays and to make a few public appearances: at Oxford in 1893, when he delivered the Romanes lecture; at the meeting of the British Association in 1894, when he spoke on the vote of thanks to the President, the Marquis of Salisbury; at the Royal Society in the same year when he received the recently established "Darwin Medal." Early in the spring of 1895, he had a prostrating attack of influenza, and from that time until his death on June 29, 1895, he was an invalid. He was buried in the Marylebone cemetery at Finchley, to the north of London.

Huxley was of middle stature and rather slender build. His face, as Professor Ray Lankester described it, was "grave, black-browed, and fiercely earnest." His hair, plentiful and worn rather long, was black until in old age it became silvery white. He wore short side whiskers, but shaved the rest of his face, leaving fully exposed an obstinate chin, and mobile lips, grim and resolute in repose, but capable of relaxation into a smile of almost feminine charm.

He was a very hard worker and took little exercise. Professor Howes describes a typical day

as occupied by lecture and laboratory work at the College of Science until his hurried luncheon; then a cab-drive to the Home Office for his work as Inspector of Fisheries; then a cab home for an hour's work before dinner, and the evening after dinner spent in literary work or scientific reading. While at work, his whole attention was engrossed, and he disliked being disturbed. This abstraction of his attention is illustrated humorously in a story told by one of his demonstrators. Huxley was engaged in the investigations required for his book on the Crayfish, and his demonstrator came in to ask a question about a codfish. "Codfish?" said Huxley; "that's a vertebrate, isn't it? Ask me in a fortnight and I'll consider it." While at work he smoked almost continuously, and he enjoyed the pleasure of the table as much as his dyspepsia and his doctor allowed him. He was devoted to music, regarding it as one of the highest of the æsthetic pleasures. He tells us himself:

"When I was a boy, I was very fond of music, and I am so now; and it so happened that I had the opportunity of hearing much good music. Among other things, I had abundant opportunities of hearing that great old master, Sebastian Bach. I remember perfectly well—although I knew nothing about music then, and, I may add, know nothing whatever about it now—the intense satisfaction and delight which I had in listening, by the hour together, to Bach's fugues. It is a pleasure which remains with me, I am glad to think; but, of late years, I have tried to find out the why and wherefore, and it has often occurred to me that the pleasure derived from musical compositions of this kind is essentially of the same nature as that which is derived from pursuits which are commonly regarded as purely intellectual. I mean, that the source of pleasure is exactly the same as in most of my problems in morphology—that you have the theme in one of the old masters' works followed out in all its endless variations, always appearing and always reminding you of unity in variety."

He had a hot temper, and did not readily brook opposition, especially when that seemed to him to

be the result of stupidity or of prejudice rather than of reason, and his own reason was of a very clear, decided, and exact order. He had little sympathy with vacillation of any kind, whether it rose from mere infirmity of purpose or from the temperament which delights in balancing opposing considerations. He said on one occasion:

"A great lawyer-statesman and philosopher of a former age—I mean Francis Bacon—said that truth came out of error much more rapidly than out of confusion. There is a wonderful truth in that saying. Next to being right in this world, the best of all things is to be clearly and definitely wrong, because you will come out somewhere. If you go buzzing about between right and wrong, vibrating and fluctuating, you come out nowhere; but if you are absolutely and thoroughly and persistently wrong, you must, some of these days, have the extreme good fortune of knocking your head against a fact, and that sets you all straight again. So I will not trouble myself as to whether I may be right or wrong in what I am about to say, but at any rate I hope to be clear and definite: and then you will be able to judge for yourselves whether, in following out the train of thought I have to introduce, you knock your heads against facts or not."

The particular suggestions to which these remarks were the characteristic introduction related to definite problems of education, that is to say, to questions upon which some action was urgent. It was in all cases of life, in science or affairs, that Huxley was resolute for clear ideas and definite courses of conduct. No one ever took greater care to satisfy himself as best he could as to what was right and what was wrong; but where action rather than reflection was needed, then his principle was to act, and to know definitely and clearly why you acted and for what you acted. In matters of opinion, on the other hand, he was all for not coming to a definite opinion when the facts obtainable did not justify such an opinion. In thought, agnosticism, the refusal to accept any ideas or principles except on sufficient evidence; in action, positivism, to act

promptly in definite and known directions for definite and known objects : these were his principles.

Another aspect of the same trait of character, he shewed in an address to medical students at a distribution of prizes. After congratulating the victors he confessed to "an undercurrent of sympathy for those who have not been successful, for those valiant knights who have been overthrown in their tourney, and have not made their appearance in public." After recounting an early failure of his own, he proceeded :

"I said to myself, 'Never mind; what's the next thing to be done?' And I found that policy of 'never minding' and going on to the next thing to be done, to be the most important of all policies in the conduct of practical life. It does not matter how many tumbles you have in this life, so long as you do not get dirty when you tumble; it is only the people who have to stop to be washed and made clean, who must necessarily lose the race. You learn that which is of inestimable importance—that there are a great many people in the world who are just as clever as you are. You learn to put your trust, by and by, in an economy and frugality of the exercise of your powers both moral and intellectual; and you very soon find out, if you have not found it out before, that patience and tenacity of purpose are worth more than twice their weight of cleverness."

All Huxley's work was marked by a quality which may be called conscientiousness or thoroughness. Looking through his memoirs, written many years ago, the subjects of which have since been handled and rehandled by other writers with new knowledge and with new methods at their disposal, one is struck that all the observations he made have stood their ground. With new facts new generalisations have often been reached, and some of the positions occupied by Huxley have been turned. But what he saw and described had not to be redescribed; the citations he made from the older authorities were always so chosen as to contain the exact gist of the writers. These qualities, admirable in scientific work, became at once admir-

able and terrible in his controversial writings. His own exactness made him ruthless in exposing any inexactness in his adversaries, and there were few disputants who left an argument with Huxley in an undamaged condition. The consciousness which he had of his own careful methods, added to a natural pugnacity, gave him an intellectual courage of a very high order. As he knew himself to have made sure of his premisses, he did not care whither his conclusions might lead him, against whatsoever established doctrine or accepted axiom.

There was, however, a strong spice of natural combativeness in his nature, the direct result of his native and highly trained critical faculty. He tells us that in the pre-Darwinian days he was accustomed to defend the fixity of species in the company of evolutionists and in the presence of the orthodox to attack the same doctrine. Later in life, when evolution had become fashionable, and the principles of Darwinism were being elevated into a new dogmatism, he was as ready to criticise the loose adherents of his own views as he had been to expose the weakness of the conventional dogmatists.

Perhaps the most striking feature of Huxley's work as a whole was its infectious nature. His vigorous and decided personality was reflected on all the subjects to which he gave attention, and in the same fashion as his presence infected persons with a personal enthusiasm so his writings stimulated readers to efforts along the same lines. His great influence is clear in the number and distinction of the biologists who came under his personal care, and in the great army of writers and thinkers who have been inspired by his views and methods on general questions. His position as an actual contributor to science has to a certain extent been lost sight of for two reasons. In the first place, his effect on the world as an expositor of the scientific method in its general application to life has overshadowed his exact work; in the second place, his exact work itself has been partly lost sight of in the new discoveries and advances to which it

gave rise. It is therefore necessary to reiterate that, apart from all his other successes, he had made for himself an extremely distinguished position in the annals of exact science. Sir Michael Foster and Sir Ray Lankester, in their preface to the collected edition of his scientific memoirs, make a just claim for him. These memoirs, they wrote, shew that, "apart from the influence exerted by his popular writings, the progress of biology during the present century (nineteenth) was largely due to labours of his of which the general public knew nothing, and that he was in some respects the most original and most fertile in discovery of all his fellow workers in the same branch of science."

There can be little question that it was no accident that determined the direction of Huxley's career. He was a naturalist by inborn vocation. The contrast between a natural bent and an acquired habit of life was well seen in the case of Huxley and Macgillivray, his companion on the *Rattlesnake*. The former was appointed as a surgeon, and it was no part of his duties to busy himself with the creatures of the sea; and yet his observations on them made a series of real contributions to biological science and laid the sure foundation of a world-wide and enduring reputation. The latter was the son of a naturalist, a naturalist by profession, and appointed to the expedition as its official naturalist; and yet he made only a few observations and a limited collection of curiosities, and even his exiguous place in the annals of zoology is the accidental result of his companionship with Huxley. The special natural endowments which Huxley brought to the study of zoology were in the first place, a faculty for the patient and assiduous observation of facts; in the second, a swift power of discriminating between the essential and the accessory among facts; in the third, the constructive ability to arrange these essentials in wide generalisations which we call laws or principles and which, within the limits necessarily set by inductive principles, are the starting-point for

new deductions. These were the faculties which he brought to his science, but there were added to them two personal characteristics without which they would not have taken him far. They were impelled by a driving force which distinguishes the successful man from the muddler and without which the finest mental powers are as useless as a complicated machine disconnected from its driving-wheel. They were directed by a lofty and disinterested enthusiasm, without which the most talented man is a mere self-seeker, useless or dangerous to society. The faculties and qualities which made Huxley great as a zoologist were practically those which he applied to the general questions of biological theory, to the problems of education and of society, and to philosophy and metaphysics. A comparison between his sane and forcible handling of questions that lay outside the special province to which the greater part of his life was devoted, with the dubious and involved treatment given such questions by the professional politicians to whom the English races tend to entrust their destinies, is a useful comment on that value of science as discipline to which Huxley so strenuously called attention.

There can be no better way of ending this sketch of Huxley's life and work than by quoting his own account of the objects to which he had devoted himself consciously. These were:

"To promote the increase of natural knowledge and to forward the application of scientific methods of investigation to all the problems of life to the best of my ability, in the conviction which has grown with my growth and strengthened with my strength, that there is no alleviation for the sufferings of mankind except veracity of thought and of action, and the resolute facing of the world as it is when the garment of make-believe by which pious hands have hidden its uglier features is stripped off.

"It is with this intent that I have subordinated any reasonable or unreasonable ambition for scientific fame which I may have permitted myself to entertain to other ends; to the popularisation of science; to the development and organisation of scientific education;

to the endless series of battles and skirmishes over evolution; and to untiring opposition to that ecclesiastical spirit, that clericalism, which in England, as everywhere else, and to whatever denomination it may belong, is the deadly enemy of science.

"In striving for the attainment of these objects, I have been but one among many, and I shall be well content to be remembered, or even not remembered, as such. Circumstances, among which I am proud to reckon the devoted kindness of many friends, have led to my occupation of various prominent positions, among which the presidency of the Royal Society is the highest. It would be mock modesty on my part, with these and other scientific honours which have been bestowed upon me, to pretend that I have not succeeded in the career which I have followed, rather because I was driven into it than of my own free will; but I am afraid I should not count even these things as marks of success if I could not hope that I had somewhat helped that movement of opinion which has been called the New Reformation."

INDEX

A

ABERDEEN, 29
Admiralty, 27, 56, 57
Agassiz, 76, 97, 103
Age of the earth, 87
Agnosticism, 230, 232, 234
Ahriman, 253
Alternation of generations, 62
Ameghino, 142
American Addresses, 79
Amphibia, 77
Amphioxus, 65, 136
Anatomy, Vertebrate, 131
Anchitherium, 82, 84
Animal kingdom, 46, 47
Anoplotheridæ, 94
Anthropoids, 148
Apes, 145, 152
Appendicularia, 63
Archæopteryx, 138
Archetype, 66, 69
Arctogœa, 141
Argyll, Duke of, 238
Aristotle, 21, 105
Arnold, Matthew, 181
Ascidians, 63, 64
Association, British, 77, 124
Authority, 223, 226
Australia and America, land connection, 142

B

BAER, VON, 21, 48, 53, 64, 69, 101
Balfour, F., 137
Barrier Reef of Australia, 32
Basi-cranium, 134
Beagle, 39, 40
Beche, Sir H. de la, 70
Belief, 224
Beneden, van, 66
Berkeley, 210, 211, 214
Bible, 87, 184, 187, 189, 227, 229, 235, 247, 248
Bibliolatry, 227
Birds, 70, 137
Blainville, de, 82
Blasphemy, 231
Booth, "General," 207
Brahma, 259
Brain, 160
Breeding, 130
Brooks, W. K., 99
Buckland, Dean, 87
Buddhists, 259
Buffon, 29, 96
Burnett, Sir W., 24, 54
Busk, George, 57

C

CABANIS, 219
Cana, Miracle at, 246
"Capacity-catcher," 196
Carlyle, 71, 72, 116
Catastrophism, 88
Catholicism, 126, 237
Cells, 60
Challenger, 28
Chalmers, Rev. Dr T., 87
Chambers, R., 69
Chamisso, 61
Chance, 221
Charing Cross Hospital, 22
Chimpanzees, 151
Chondrocranium, 134

Christianity, 126
Chronology, Biblical, 238
Classical education, 181
Classification, 48, 49
Clergy, 228
Clericalism, 228
Clodd, E., 96, 97, 130
Cœlentera, 52
Cœlomata, 53
Commissions, Royal, 198
Contemporaneity in geology, 87
Cookery in schools, 185
Cope, E. D., 78, 99
Cosmogony of Hebrews, 235
Cosmos, 221, 249
Cowper-Temple Clause, 184
Crayfish, The, 156, 169, 208
Creation, 240
Criticism, Biblical, 235
Croonian Lecture, 75
Crustacea, 55, 77
Ctenophora, 52
Culture and science, 180
Curriculum, Medical, 179
Cuvier, 20, 21, 47, 49

D

DARWIN, CHARLES, 39, 40, 68, 71, 95, 97, 98, 103, 105, 118, 221, 227, 235, 259
Darwin, Erasmus, 96
Darwin medal, 113
Darwinism, 100, 109, 115
Davy, 15
De la Beche, Sir H., 70
Deluge, 225
Descartes, 210, 211
Dewar, Sir J., 201
Dinosaurs, 78
Distribution, Geographical, 139
Dogma, Christian, 224
Doubt, 224, 257
Drawing, 17
Dredging, 34

E

EARTH, AGE OF, 87, 91, 92
Eastbourne, 263
Ecclesiasticism, 230
Education, 183
Education and science, 164
Education, Classical, 181
Education, Elementary, 183, 188
Education-ladder, 196
Education, Liberal, 195
Education, Technical, 192, 194
Education, University, 191
Edinburgh Review, 119, 120
Embryology, 137, 154, 171
English, Huxley as a reader of, 206
Eohippus, 85
Erdkunde, 167, 168
Ethics, 249
Eutheria, 143
Evil, 251, 257
Evolution, 64, 67, 69, 77, 95, 97
Evolution and materialism, 219
Evolution, Battle for, 115
Evolution, Darwin's contribution to, 98, 99
Evolution, History of, 126
Evolution, Huxley's early views on, 68, 101-103, 128
Evolution, Pre-darwinian, 104

F

FANNING, MR., 73
Faraday, 15
Fayrer, Sir J., 24
Fisgard, H.M.S., 55
Fishes, Palæozoic, 76, 77
Flower, Sir W., 146
Fly, 29, 30
Foote, M., 231
Forbes, Edward, 56, 70, 71, 105

Fossils, 76
Foster, Sir M., 45, 56, 175, 268
Freedom of thought, 223

G

Garnier, Prof., 150
Gasteropoda, 65
Gegenbaur, C., 66
Genesis, 225, 240
Geographical distribution, 139
Geological Club, 225
Geological Society, 86, 87, 92
Geology, 76, 86, 89, 239
Gladstone, W. E., 238
Goethe, 104
Good, 251
Gorilla, 94, 132, 133
Greek, 21, 206
Groos, Prof., 153

H

Haeckel, Prof. E., 97
Hair-sheath, Huxley's layer, 23
Hand of man and apes, 159, 161
Haslar Hospital, 25
Heart, Mitral valve of, 171
Heathorn, Miss H. A., 72
Hebrew cosmogony, 236
Heine, 251
Hertwig, 136
Hipparion, 82
Hippocampus, 160
Hobbes, 211
Homotaxis in geology, 87
Hooker, Sir J. D., 56, 71
Horse, Pedigree of, 82, 83
Howes, Prof. G. B., 169, 263
Humanitarianism, 185
Humboldt, 45
Hume, David, 210, 211, 215, 233, 244
Hunter, 15
Hutton, 88
Huxley, birth, 16; parents, 16; school-days, 18; study of medicine, 19; Charing Cross Hospital, 22; first original paper, 23; graduates at London University, 24; becomes M.R.C.S., 24; Haslar Hospital, 25; *Rattlesnake*, 26; work at Sydney, 44; first paper to Royal Society, 44; elected F.R.S., 56; receives Royal Medal, 45; leaves *Rattlesnake*, 55; early days in London, 56, 57; appointment to Geological Survey and School of Mines, 70; Fullerian Professor, 74; courtship and marriage, 72, 74; examiner, 74; Croonian lecturer, 75; visit to America, 79; Secretary and President of the Geological Society, 86, 87; receives Wollaston medal, 86; accepts Darwinism, 107; receives Darwin Medal, 113; Hunterian Professor, 132; Royal College of Science, 175; London School Board, 184; Royal Commissions, 198; Privy Councillor, 199; Romanes Lecture at Oxford, 252; ill-health and retirement, 263; death, 263; summary of life, 261; personal appearance, 263; summary of scientific work, 267.

I

Ichthyopsida, 143
Idealism, 213, 216
Individuality, 88

Infallibility, 126, 226
Inspiration, 238
Institution, Royal, 68, 74, 201

J

JOHNSON, SAMUEL, 211
Jones, Wharton, 23, 48
Jukes, Professor, 29

K

KANT, 90, 251
Karma, 257
Kelvin, Lord, 91
Kölliker, 66
Kowalevsky, 65

L

LABORATORY WORK, 173, 175
Labyrinthodonts, 77
Lamarck, 96, 97, 99, 102
Languages, Modern, 20
Lankester, Sir E. Ray, 17, 65, 67, 99, 175, 180, 263, 268
Latin, 206
Lawrence, Sir W., 144
Life, Origin of, 220
Linnæus, 48, 49
Locke, 216
London School Board, 184
London University, 24, 193
Loyola, 251
Lucas, Mr., 117
Luther, 251
Lyell, Sir Charles, 88, 103, 225, 239

M

MACGILLIVRAY, JOHN, 29, 33
MacGillivray, W., 29, 104
Macmillan & Co., 167
Mammalia, 143
Man and apes, 144, 146
Manes and Manicheism, 253
Man's Place in Nature, 146
Manual of Invertebrata, 171
Manual of Vertebrata, 171
Marsh, Professor, 79, 83
Mason, Sir J., 180
Materialism, 210, 213, 217
Matter, 211, 214
Matthew, Patrick, 104
Medicine, Training for, 177
Medusæ, 44, 49, 50, 51
Mertens, 64
Mesohippus, 84
Metaphysics, 211
Metatheria, 143
Microtomes, 172
Miracles, 235, 244
Missionaries, 251
Mivart, St. George, 237, 238
Mollusca, 55, 65, 68
Morality, 229
Morley, Lord, 210, 249
Moseley, H. N., 28
Müller, Johannes, 21, 48, 64
Music, Huxley and, 264

N

NAPLES ZOOLOGICAL STATION, 171
Nature, 204
New Testament, 243
Nirvana, 259
Noah's deluge, 225
Norwich, Bishop of, 27, 44

O

OKEN, 132, 133
Old Testament, 240
Origin of Species, 95, 107, 111, 113, 235
Ormuzd, 253
Orohippus, 84
Osborn, H. F., 96, 174

Owen, Sir Richard, 75, 105, 119, 121, 124, 132, 133, 145, 160
Oxford, 124, 252

P

PAIN, 256, 258
Palæontology, 93, 131
Palæotherium, 82, 84
Pascal, 126
Pessimism, 258
Phillips, Professor, 78
Phosphorescence, 63
Physical training, 185
Physiography, 168, 208
Physiology, Elementary, 169
Plankton, 42
Platonism, 217
Polyps, 51
Priestley, Joseph, 15, 230
Primers of Science, 167
Privy Council, 199
Protestantism, 126, 224
Protohippus, 82, 84
Protoplasm, 60
Prototheria, 143
Pterodactyls, 78
Puritanism, 231

Q

QUARTERLY REVIEW, 119, 120

R

Rattlesnake, 26, 27
Reade Lecture, 145
Reformation, Protestant, 224
Regions, Zoological, 141
Religion, 184, 186
Reptiles, 77
Research, Endowment of, 193
Richardson, Sir J., 25
Robertson, Charles, 174
Rolleston, Professor, 174
Romanes, J. G., 151, 252
Romanes Lecture, 205, 252
Roscoe, Sir H., 167
Rosse, Earl of, 45
Royal College of Science, 175, 198
Royal Institution, 58, 60
Royal Society, 44, 45, 56, 75, 113
Rutherford, Prof., 175

S

SALISBURY, MARQUIS OF, 128
Salps, 61
Salt, Dr., 19
Salter, Mr., 76
Sargasso weed, 42
Sauropsida, 143
Savages, 35
Schwann, 60
Science and culture, 180
Science and education, 164
Science, Applied, 193
Sclater, P. L., 139, 140
Scriptures, 237
Sedgwick, Prof., 87
Selection, Natural, 99, 109, 129
Skull, 131-134
Spencer, Herbert, 71, 97, 99, 127
Stanley, Capt. Owen, 26, 27, 44
Stanley, Dean, 27
Stevenson, R. L., 170
Stewart, Balfour, 167
Stoics, 229, 257
Stokes, Sir G., 45
Style, 205
Suarez, Father, 207
Supernaturalism, 217
Superstition, 233
Surgeons, Royal College, 25, 132
Survey, Geological, 70
Suspensoria, 135
Sydney, 44, 72

T

TAILS, 64
Tapirs, 85
Teachers, Training of, 190
Technical education, 192
Teleology, 221, 222
Testament, Old, 240; New, 243
Theology, 186
Thomson, Sir W. (Lord Kelvin), 91
Times, The, 75, 117
Toronto, 57
Tow-net, 34
Tunicates, 61, 64
Tyndall, J., 56, 57, 71
Types, 47, 68, 94, 101

U

UNIFORMITARIANISM, 88
University of London, 193
University of Toronto, 193

V

VARIATION IN ANATOMY, 163
Vertebral theory of skull, 133
Vertebrates, 48, 131, 143
Vestiges of Creation, 69, 102,
Vivisection, 199
Voltaire, 249
Vosmaern, 151

W

WALLACE, A. R., 104, 258
Weight of brains, 161
Weismann, A., 99
Wells, W. C., 104
Wilberforce, Bishop, 119, 120, 122, 124, 125
Willey, A., 65
Workmen, Lectures to, 200

Z

ZOOLOGICAL GARDENS, 151
Zoophytes, 51

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